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VOLUME III.

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WITH 257 ILLUSTRATIONS

CORRECTED IMPRESSION

London:

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New York

SPON & CHAMBERLAIN, 123 LIBERTY STREET

1917

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Jointing Steam and Water Pipes.

Flanged Pipes. — The ideal flange joint is that made by scraping, which, if properly done, is water-, steam- and air-tight, and all the packing it requires is a thin smear of red-lead in oil. This joint is used for covers of engine cylinders, steam-chests and for sliding faces, but as it is a costly joint—costly in labour—it is seldom used for any ordinary pipe work.

The more ordinary finish to flanged ends is obtained by planing or turning. This gives a true surface, but as it consists of minute lines, the joint cannot be made steam- or water-tight without some kind of packing material coming between the two faces. Numerous materials have been used for this, such as copper wire, sheets of thin copper stamped with concentric corrugations, canvas, millboard, asbestos-board, prepared canvas, etc. If the flanges have well-finished faces, quite thin material like canvas, or fine wire gauze, can be used with advantage, but if the faces are coarsely finished (as they are for moderate priced work) the thicker materials are used. India-rubber "insertion" sheet, consisting of one or more sheets of canvas with rubber outside and between (all amalgamated like a thick waterproof material) is suited for hot-water pipes, but is not used freely for steam work. A composition which appears to be common rubber with graphite is largely used in America for low-pressure steam pipes, but for high-pressure work rubber is not in favour. Asbestos card-board answers well, but, like rubber is not cheap.

In using the customary red and white lead mixture for making joints, the quantity may be liberal with low-pressure hot-water joints, but with steam at a fair or high pressure, it should be used sparingly or it may blow out.

Many consider wire gauze preferable to other materials for flanged joints, this gauze being used with white and red lead paste, the gauze acting the part of a large number of small cells for the paste to prevent it spreading unevenly or blowing out. Fig. 1 shows how the gauze should be cut out, with bolt-holes all prepared, preparatory to its being used. Before the gauze collar is put in place, it has a thin coat of red and white lead paste. Fig. 2 is a section of a joint showing the gauze collar between the flanges.

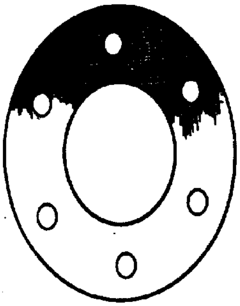

Fig. 1.

A quite common plan of making a joint between two turned flange faces is by means of a length of copper wire, about 18 to 20 G., curved round to come as Fig. 3. When the flanges

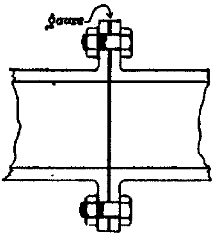

FIG 2.

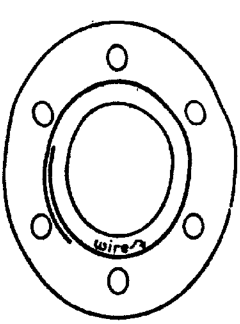

FIG. 3.

are drawn together, the soft wire is compressed, and makes the junction steam-tight. With this, as with all joints, it is important that the screwing-up and tightening of the bolt nuts be done gradually and evenly all round. Copper wire, used in this way, is very useful for making joints, when the flanges or faces are narrow and not suited for a broad washer.

In dealing with still rougher surfaces, the flanges not being turned or faced, washers of comparatively thick material must be used. These may be of millboard, asbestos-board, rubber insertion, or rubber composition. The thickness may be from $\frac{1}{16}$ in. to $\frac{1}{8}$ in. according to the roughness of the surfaces. The two former are usually given a coat of red and white lead paste, and when the whole of the bolts are drawn up, the materials give sufficiently to accommodate themselves to the inequalities of the surfaces. In certain instances, such rough faces are met with that the flanges have to be shaved thinner in places to take the risen parts, but this is seldom the case unless it is small jobbing work. In all contract work it pays to have the flanges faced, if ever so roughly.

A joint in common vogue, not perhaps so much for large contract work as for small and repair jobs, is made by one or two turns of tarred twine, first smeared with red and white lead paste, wound round like the copper wire shown on Fig. 3. Or, instead of the twine, a ring or grummet of hemp may be made, though the hand-made grummet is not likely to be so evenly twisted as the machine-made twine. A plait of tarred twine, made into an endless ring, can also be used, and is better than single strands in some cases. It serves well for manhole or mudhole joints of boilers.

Socketed Pipes.—Referring now to jointing pipes with socket and spigot ends (used for water and gas, rarely for steam), there are three ways of jointing these.

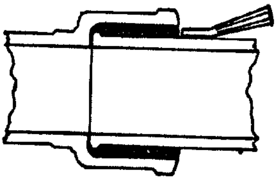

FIG. 4.

(*a*) *The Caulked Lead Joint.*—Fig. 4 illustrates this. When the spigot has been inserted in the socket, lengths of yarn are wound round and driven

in by the caulking tool shown, the yarn being caulked in soundly and carefully, as it is this that really makes the joint water-tight. Following this, the remaining space is filled with lead, poured in in a molten state, and when set, caulked hard to render it a solid and firm backing for the yarn. This work having to be done while the pipe lies horizontally, some stiff clay is prepared and then wrapped round to cover the joint space all except a hole at the top into which the molten lead is poured. When the lead has set, the clay is removed, and the caulking makes it firm and hard.

(b) Another method of jointing socketed pipes is by using iron borings or red and white lead, or Portland cement, or molten sulphur (poured in like lead). Sulphur is now seldom used, while Portland cement is not considered reliable with metal pipes. The use of iron borings and red and white lead is described a little later in this article.

(c) In jobbing work it is commonly required to insert a piece of pipe when the ordinary fixed socket cannot be got in. In such a case a loose socket or thimble is employed. This is a loose collar, like a long double-ended socket, and, when put in position over the two plain ends of pipe, is caulked at both ends, as Fig. 5.

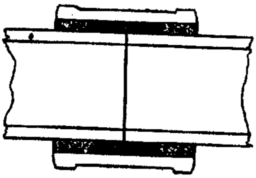

FIG. 5.

Check Flanges.—When heavy pressure is to be withstood, as in hydraulic work for example, what are known as "check" flanges are employed. In this method one part of the flange is recessed into the other, so that the packing material may not be blown out. Fig. 6 is a simple example: a square-edged ring projects on one flange, this fitting into an annular channel recessed in the other

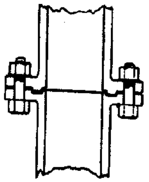

FIG. 6.

flange. The packing material, probably a collar of lead or rubber composition, coming in the other. This, as will be seen, makes a very sound joint. Another joint of this kind is shown in Fig. 7, this being largely

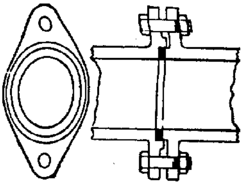

FIG. 7.

used in hydraulic work whether the pressure be high or low. It will be seen to consist of male and female gland flanges—cast on the pipes—checked into each other. An ingenious detail is the bevelling of the two faces that come against the packing material, the effect of this being to force the packing material outwards and not inwards. The latter would mean a possible projection inside the pipe, while the former only tends to make the joint more sound.

Jointing Cast-iron Tank Plates.—Figs. 8 and 9 illustrate two methods of jointing the flanges of cast tank plates. In the former, the caulking is done from the outside, while with the other it is done from

inside the tank. The caulking space is from $\frac{3}{8}$ in. to $\frac{1}{2}$ in. and the material used for the joint is usually iron borings or rust cement, caulked in. The

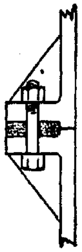

FIG. 8.

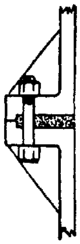

FIG. 9.

bolts, if loosely fitting, should have grummet washers, or there may be leakage from a bolt hole here and there.

Cast-iron Hot-water Pipes.—There are several ways of jointing the ordinary cast hot-water pipe, the cheapest lasting joint being made with iron borings and known as the rust joint.

Rust Joint.—(*a*) Take 80 to 100 parts by weight, of iron borings, 2 parts of powdered (flour) sulphur, and 1 part of powdered sal-ammoniac; thus, to 1 cwt. of borings there would require to be about $2\frac{1}{4}$ lb. of sulphur, and, say, 18 oz. of sal-ammoniac. These must be well mixed in a dry state, then have water added and mixed until the mass is of a uniform moistness. This should be done from 1 to 2 hours before the material is required for use.

Iron borings are supplied cheaply (3*s*. 6*d*. to 4*s*. per cwt.) by those firms who deal in cast hot-water pipes. Borings should be well pounded, if they appear to be too coarse.

In making the joint, it must be understood that the yarn, or gaskin, first caulked in, is the actual joint-making material, and the boring mixture, when it has set hard, only serves to back this up and keep it sound. On this account the water should not be turned into the pipes until the borings have set, and although very little thought is given to this in glasshouse work, in which the pressure is so light, yet even in this case the joints should be allowed from one to three days for setting, i.e. not less than one day for 2-in. pipe, one and a half to two days for 3-in. pipe, and two to three days for 4-in. pipe. This is for horticultural work, or wherever the pressure is practically *nil*, and, as stated, these should be the least times allowed for the borings to set.

A still slower setting cement is made by mixing 2 parts sal-ammoniac, 1 part flour sulphur, with 200 parts of borings.

In making the joint a length of yarn, making about three turns round the pipe, is first caulked soundly in, and this is followed by other lengths until the socket is a little more than half full. As regards the precise quantity, various fitters have different ideas, and while some consider the joint should be half yarn and half borings, others caulk in yarn until only $\frac{1}{2}$-in. space is left for the borings. Doubtless, this is sufficient if so small a quantity can be got to set well, and on the latter account about $\frac{3}{4}$ in. of borings, and from this to 1 in. may be found best for the larger pipes (3-in., 4-in. or larger).

The chief reason for limiting the quantity of borings is its liability to crack the socket owing to its expanding a little as it sets. If it were not for this, the borings might be used liberally, as it is a cheap material, and would reduce the quantity of yarn required. It must be plainly stated that a man's capability in joint-making with this material is quickly known by whether he gets cracked sockets or not, and many tons of pipe have been rendered useless through this. The best advice that can be given is to use

only a reasonably small quantity of borings, and to caulk or press them in evenly, but not too hard. They should not be used too fresh, yet no more must be mixed (that is, moistened) than can be used the same day, as they will not keep long without setting.

An American journal states that 10 parts borings with 3 parts chloride of lime, mixed to a paste with water, makes a good joint not so liable to split the sockets. Yarn is caulked in in the usual way. This joint sets in 12 hours.

Cement.—(*b*) Although an engineer does not consider Portland cement a proper material to use for this purpose, yet an immense number of joints, in glasshouse work, have this as the sole material to back up the yarn. It serves very well, if it is of good, new quality. Borings can be mixed with it, if desired.

When a few joints only are required, and borings are not readily obtainable, red and white lead putty may be used. With this a length of yarn is first caulked in, then a layer of the putty, then yarn and putty alternately until the socket is full. To make a good job of this, some of the putty should first be thinned with boiled oil, and the socket and spigot painted with this on the surfaces where the packing material is about to come. This joint is not a cheap one, nor does it set quickly.

(*c*) A good substitute for the red and white lead joint is a mixture of two parts dry slaked lime or whiting (or powdered chalk will do), one part of litharge and two parts sand, these being mixed with boiled linseed-oil to make a putty. This is caulked in alternate layers with yarn as last described.

Rubber.—(*d*) A joint that is largely used when the conditions will admit is made with a plain rubber ring. A ring of round cord rubber, of bare ½-in. thickness, is stretched over the spigot end of the pipe, and this is then thrust into the socket. If the socket is an even casting, and the ring of proper thickness, a sound joint is obtained without doing anything else. Where rubber ring joints are used, no other provision for expansion is needed, but it will be seen that full provision must be made for supporting the pipes, as the joint has no rigidity whatever. Sometimes the ring is backed up with cement to keep it firm. A rubber ring makes a good provision for expansion if used here and there on long runs of rigidly jointed pipes. The rubber ring joint is largely used by professional growers, as the men employed on the grounds can readily put up new runs of pipe, or alter old ones, with this joint. The rings are stocked by all firms supplying the pipe.

Compressed Rubber Ring.—(*e*) A form of joint that is now being used largely with every success consists of a rubber ring, which is compressed when the joint is tightened up. The tightening is done by bolts and nuts, and the ends of the pipe, or one end, at least, are cast to a special design for this purpose. An early pattern of this joint is Jones's patent, illustrated by the two drawings of Fig. 10. The statement just made that the pipes have to be provided with specially designed ends must be with-

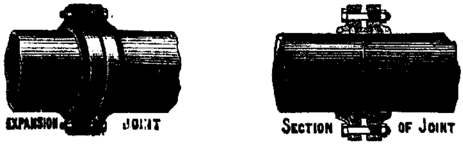

FIG. 10.

drawn in this case, as the pipes and fittings have all quite plain ends, not even a socket being used. This is the joint sent out with the complete apparatus which is sold for amateur's own erection, for anyone with but a slight knowledge of tools can make up this joint. It consists of three iron collars and two rings of square rubber. The two outer collars, as will be seen when drawn together, compress the rubber rings on to the inner metal collar, and this makes a perfectly sound joint. It is not intended that this joint be used for works in which a high pressure is felt, consequently it is not suited for the basement mains of a heating apparatus in a high building.

The same makers have a joint designed for bearing high pressures, this being illustrated by Fig. 11. This necessitates the use of specially designed ends to the pipes and fittings, these ends, when drawn together, compressing a rubber ring on an interior iron collar, as shown.

The two illustrations of Fig. 12 show Richardson's Patent Universal joint, as made by the Meadow Foundry Co. This is a reliable joint for high pressures, and it will be seen that, as one end of each bolt is a hook, bearing on a shoulder, a pipe or fitting can be twisted round and fixed at any precise angle required.

(*f*) The illustrations of Fig. 13 show Messenger's joint. This will bear pressure and possesses the advantage of only requiring one end of the pipe to be of special design, while the other end is plain. By this means a pipe can be cut on the job, whereas with joints requiring two specially designed ends to the pipes and fittings there usually have to be some odd lengths cast to order to finish a job with. It may be explained, however, that the makers of joints requiring two special ends always keep a fitting or joint that can be used on a cut pipe and so save the time that must be allowed for casting an odd dead length; or, as special lengths are a common demand, the makers hold themselves in readiness to cast these at short notice and when a high pressure has to be withstood, it is better to wait a day or two for this than use a plain-ended cut pipe. When heavy pressures have to be borne, say 70 ft. and upwards, the writer prefers that both ends of pipes and fittings be specially moulded.

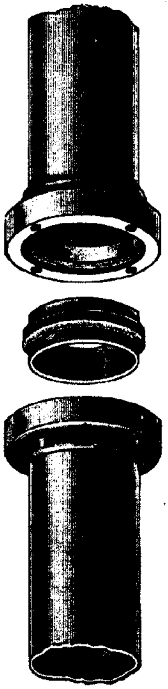

FIG. 11.

(*g*) A fitting that is associated with cast pipes is the "saddle," Fig. 14. This is to enable a wrought pipe branch connection to be made, when the cast pipes cannot be drilled or taken down for the insertion of a tee. A hole is cut in the pipe with a diamond-point

chisel, and when it is of suitable size, the saddle is bedded on with red-lead putty and hemp, and then drawn down tight on to the pipe by the nuts shown.

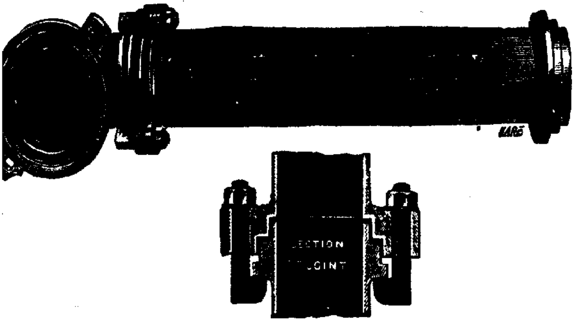

FIG. 12.

The hole in the pipe need only be of a fair shape and does not need to be carefully finished or tapped with a thread. The tapping for the wrought

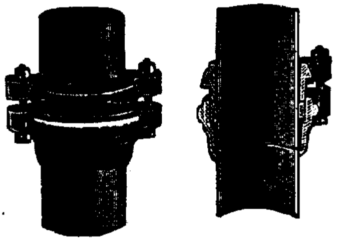

FIG. 13.

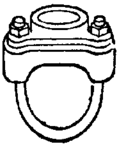

FIG 14.

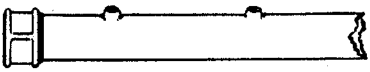

FIG. 15.

pipe is in the hole shown in the saddle.

(*h*) When a number of small branch connections have to be made on cast mains, the majority of makers are prepared to cast bosses or stubs on some of the lengths of pipe, as Fig. 15, these bosses being drilled and tapped for wrought pipe. This comes much cheaper than inserting a pair of tees for each small branch, for the tees must be provided and fitted with blank ends to the outlets, these ends being drilled and tapped for wrought pipe. Where, say, a 3-in. one-pipe main is run round a basement to carry

about a dozen radiators, the insertion of two-dozen tees is a real trouble and expense compared to having the bosses just described.

Tees, when used for this purpose, should have the blank ends to the outlets drilled eccentric; that is, the hole for the wrought pipe should come out of the centre and close to the upper edge of the blank end.

THE KALEIDOSCOPE.

THIS is an instrument—usually considered a toy—which exhibits the effects of multiple reflection. An unarranged group of fragments of coloured glass may seldom make an attractive design, but when the group of pieces is multiplied, say six times, each reflection arranging itself in order around the original, the result is seldom otherwise than a pleasing design, the effect being sometimes surprisingly beautiful. The article, as sold, ranges in cost from one penny to several shillings, the principle being alike in all, but the materials used in construction differing greatly. In the better qualities, too, a magnifying eyepiece (a lens of low power) is used to improve the effect.

Fig. 16 will serve to describe the necessary parts. The outer case is a tube of cardboard or metal. The eye-piece at one end may be a circular piece of plain clear glass with a mask of paper over it having a $\frac{3}{16}$-in. to $\frac{1}{4}$-in. hole in the centre, or it may be a more elaborate stamped metal eye-piece; or, as stated, it may have a low-power (magnifying) lens fitted. At the opposite extremity of the tube, the extreme end is fitted with a circular piece of plain ground (frosted) glass, while inside the tube about $\frac{1}{4}$ in. from the outer glass is a circular piece of plain clear glass. This space between the glasses is to form a cage or cell in which the material to be viewed is put. Were it not that the material *must be confined to this space, the inner glass would* not be needed, as its purpose is merely to prevent the loose material getting into the tube where it could not be seen. Between the two ends of the tube there extends a pair of mirrors, as can be seen, these mirrors being pieces of looking-glass about 6 in. to 9 in. long by 1 in. to 2 in. wide (according to the size of instrument intended), and it is essential that they be placed at an angle which is an aliquot part of 180°.

Thus they can be 30°, 45°, 60°, etc., but, as will be seen directly, a 45° angle is most common. The two mirrors thus form two sides of a triangle, while the third side is made up of any black material (black velvet, cloth, or paper), as Fig. 17 shows. When described, the required effect can only be obtained when the two mirrors meet at the bottom (as Fig. 17) with the black surface above. This is because the necessary reflections in the mirrors can only be obtained when the material appears to be grouped in the

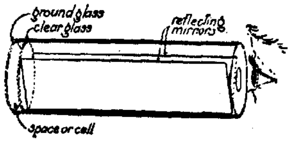

FIG. 16.

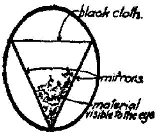

FIG. 17.

the material has been put into its cell and all parts secured by pasted paper (or metal caps and bands), the instrument is completed. The materials to be viewed consist of fragments and splinters of coloured glass, threads of coloured glass bent in any fantastic form, and pieces of thin wire (bent) and wire gauze. These latter things, while lending themselves to make a pattern, are not transparent and will appear black.

When viewed through the eye-piece the fragments of material will be seen grouped in disorder within the triangular space, as shown in Fig. 17, but the effect of the mirrors will be to produce, apparently, six triangular spaces arranged as Fig. 18 shows, one being the actual one with five reflected copies, and, as will be noticed, the irregular mass of material now forms a design more or less pleasing to the eye. It is only necessary to give the instrument an occasional shake to cause new designs to constantly appear, every one differing, for it is practically impossible to get the fragments of glass to arrange themselves twice alike, or anything approaching this.

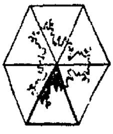

FIG. 18.

It may now be pointed out that with the instrument, designed as just angle formed by the two mirrors (as Fig. 17 shows). If the angle were formed by one mirror and one black surface, a proper set of reflections would be impossible; a part of a set could be obtained, but this is useless. Therefore, if an instrument is required with which the image may be seen however it is held, the black surface has to be replaced by a mirror, the three mirrors then ensuring a set of reflections from any angle that happens to be downwards. This arrangement admits of the instrument being held to the eye and twisted slowly with the fingers, each one-third turn causing the material viewed to take a new arrangement. It is, in fact, the best plan always to have three mirrors, but as all text-books denote a chief description to the two-mirror kind (the third mirror not being absolutely necessary), the same plan has been adopted here.

For a perfect, high-quality kaleidoscope, the mirrors should be silvered on the front of the glass. If silvered at the back (as looking-glass always is) there must be two reflections occurring from each mirror, one from the silver film and one (of less effect) from the face of the glass, and, as the silver surface is the most effective, the two silvered parts should meet at the angles, which they cannot do as the thickness of glass prevents it. Ordinary silvered glass is used, however,

care being taken to have it as thin as possible. In cheap toys, plain clear glass is sometimes used, this being given a coat of black at the back, while in the penny articles bright tinned iron (sheet tin it is called) or very thin bright sheet zinc, or a bright white alloy, is folded into a three-sided tube.

It is possible to give a pretty display by the aid of an optical (magic) lantern.

A tube of metal or cardboard about 5 in. long by 2½ in. diameter has two mirrors fitted in it, as Fig. 19 shows, and this tube is arranged to come between the lantern front and the lantern objective (the latter being removed from the lantern front to admit of this). Fig. 19 illustrates

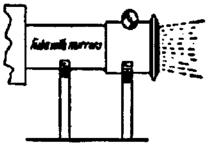

FIG. 19.

this and shows also how the tube must be supported. No eye-piece is requisite, nor is a cell needed for the fragments of coloured glass. These latter are arranged to come in a suitably prepared slide, this consisting of two pieces of plain clear glass (the size of a lantern slide) fastened together with a space between for the material to lie loosely in. The slide can be of round glasses and made to revolve, otherwise it must be shaken to make new patterns. The tube with the mirrors in it is not required to move, and, needless to say, the mirrors must form an angle at the bottom of the tube. It is probable that the lantern objective will be found of too short a focus, and a few trials must be made to adjust the lime (or other) light so as to get a properly defined picture. It will probably be found that the light must be well back and low towards one side. Trials must be made until the insertion of any small object (the loop of a hair-pin, for instance), in the position of the slide gives a clearly defined multiplied image on the screen.

KEY CUTTING AND LOCK REPAIRING.

THE necessary tools for key-cutting are as follows: hammer, anvil, vice (preferably a leg vice), a selection of files, 3-in. and 4-in. warding files, 8-in. second-cut hand, small, round, and square files, and a 3-in. and 4-in. three-square file, a hand drill, with twist-bits, large and small pair of calipers, screwdriver, and two or three small key-cutting chisels. The names of the parts of a blank are as follows (Fig. 20): *a* is the bit of which 1 is top, 2 front, 3 bottom edge. *b* is bow, or handle; *c* is pipe, or if a solid key, this part is called the pin; *d* is the shoulder. An article called a key-horse is very useful for finishing keys. It is made for a pipe-key out of a piece of $\frac{3}{16}$-in. rod iron bent into a square of which half one side is cut away, to allow the pipe to be pushed on the remaining half. For a pin-key it is made with only three sides with both ends flattened, and one is drilled out to admit pin of key, the other is dished out to allow bow end of key to rest on it. The majority of keys can be divided into three classes, warded, lever, Bramah and Yale. The main characteristic of a warded key is that the cuts are chiefly on top and bottom edge, occasionally in the centre of bit. In a lever key, steps are on the front edge, while Bramah and Yale keys are so distinctive that they need no description.

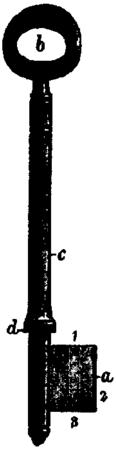

FIG. 20.

Selecting Blanks.—When selecting blank, see that in a pipe-key the bore is the same width and depth as the pattern-key, and the bit, long and wide enough to include the whole of the pattern, also that the length over all is the same.

To cut a Pipe lever latchkey. First reduce length of bit to same length as largest member of pattern-key by measuring with calipers, one leg of which is inserted in pipe, and the other at the extreme end of step; reduce width of the same by filing the end of bit nearest the bow, *not the other end*; with a file mark the position of the steps of the pattern-key on the blank. Taking the $4\frac{1}{2}$-in. ward file, the first step is cut exactly the same length and width as same step on the pattern; during this stage the key must be continually measured with the calipers to prevent cutting the steps too short; the other steps are measured and cut in the same manner. The edges of the steps must be given a full round to easily lift the levers to a proper height, this should be done with the second-cut hand file. It should be finished by being rubbed all over with fine emery-cloth and buffed. The reason for measuring from the inside of a pipe blank is the variation in the thickness of pipe-keys.

To cut a pin-key.—The pin is first reduced to the size of the pattern, and the measure taken from back of pin to front of step, and the cuttings proceeded with as for a pipe key.

To cut a Bramah key to pattern.—Select a blank the same size as pattern inside and outside, otherwise file it down; if the hole is too small, it must be drilled out. Make the small projection the same size, and if the length of pipe below small projection is longer than the pattern, it must be filed down. Place one end of calipers under bit and measure position of first cut, mark this and remaining cuts on blank with a file. Make the cuts same width and depth as pattern, measuring the depth with a piece of

fine wire. Care must be taken to make cuts exact depth of pattern.

To cut a Yale key from a pattern.—Select a blank of exactly the same corrugations, and clip both blank and key together in the vice, with the pattern key towards you. Take a small three-square file, and carefully cut V-shaped notches same depth and width as pattern; care must be taken not to injure the pattern.

To cut a solid ward Rim or Mortise key.—Provide a blank with pin and bit same size as pattern, file or saw cut across bit for bridge, then with small chisel cut away the metal required to form the steps of solid ward, finish with emery-cloth and buff-stick. Measure small space in between top edge of bit and collar on stem, give key same distance as pattern by filing away collar of key.

To cut key to a lever lock.—Remove cap plate, take off first lever and scratch I on it, mark next lever II, and so on. Place blank in vice and file down until it works the bolt, take the lever last taken out and replace in the lock, cut step in the blank until the lever is raised high enough to allow stump in the bolt to enter it, place remaining levers on, one at a time and fit as first one; screw on cap plate and finish key.

To cut Yale key to lock.—Yale lock cylinders are made in two forms, the older with a small slide on top, the newer without. If of the former make, proceed as follows: Gently push out slide, shake out springs and pins, great care must be taken not to mix these; unscrew small plate at the end, and push out inner cylinder. The blank is put in small cylinder and the bottom half of first pin dropped into its proper hole; a V-shaped notch is now cut in blank, deep enough to allow top of pin to lie flush with edge of cylinder; the remaining pins are put in and cuts made to correspond with them in the key.

To cut key to newer pattern Yale lock.—Place cylinder in vice and file top of the oblong piece of metal on top of the cylinder until the springs and pins can be taken out, cut key as in foregoing, and insert plug, spring, and pins; solder on a small piece of brass to cover opening.

To fit key to a Bramah lock. Remove cylinder and from the back of it take out two semicircular plates, which will allow inner cylinder to drop out. Select a blank and cut first notch in it, so that it will push slider down until a cut in the slider comes in line with channel in cylinder where the two plates were. Cut the others in the same manner until the two plates will revolve easily round the cylinder when the key is inserted. Replace inner cylinder, taking care that the notch in it where bit of key engages, is placed to the keyhole; screw lock together again.

To fit a key to warded lock.—Place blank in position in lock, mark position of wards and cut out with file and chisels until it will allow key to pass; look at cap plate and see if there are any wards in it, if so, cut as others. When it is impossible to remove lock for cutting key, fit a blank until it enters keyhole, then carefully smoke bit of it, insert in lock and turn; this will show the position of wards, which must be cut out until the key will pass. Keys to *common* lever locks can be cut in the same way, by filing those steps which are marked heaviest by the levers.

Repairs to locks.—The most common defect to which locks are subject is the breaking of the springs; these can be obtained of most ironmongers and replaced. When a lever spring breaks, take out pieces and get new one same width and length; fix it by closing up end of lever. In Mortise locks the follower usually wears small; a new one can readily be obtained and fitted if needed with a file. The keyholes in locks fixed on exterior doors often become worn from constant use and rust. The plate must be removed and placed underside up upon the anvil; then with a

centre-punch make a series of indentations round the keyhole which will reduce it; with a small round file clean up the hole till the key fits. When the hole is too large to be so treated, a plate of brass with keyhole cut in it is riveted to plates of lock on both sides; the key must then have its collar filed back the same distance as the thickness of the brass plate. A key after much wear will fail to throw the bolt the full distance; place it on the anvil with the bit towards you, and with a pulling motion gently hammer it long enough.

Altering Locks.—When a bunch of keys is lost, it is not necessary to have new locks, as they can be altered so that the original keys will not fit them, in the following manner. In a lever lock, remove cap plate, take out levers and replace in a different order. In a Yale lock, take out pins and reset in new order. In a Bramah, alter position of sliders. In a warded lock, fix a new ward or put an iron rivet through plate, so that the passage of key will be stopped; and then cut keys to fit. Whenever possible it is advisable to clean all locks; to remove grease and dust use a rag dipped in paraffin; wipe clean and lubricate working parts only with good sweet oil. When choosing locks it is advisable as far as possible to have good quality, also to choose those with brass bushed keyholes, as this very considerably increases the life of the lock. (W. Frewer.)

KITCHEN BOILERS,

AND THEIR DEFECTS.

Sources of Danger.—That there is real danger associated with the closed boiler—the bath boiler, as it is called—there can be no doubt. The number of explosions occurring with these is much greater than with steam boilers, and it is the rule, rather than the exception, for loss of life to occur when an explosion occurs. Realising this, it cannot be too widely known that a simple precautionary measure can be taken that will quite obviate all risks, this measure being the provision of a safety-valve. Exhaustive enquiries have been made, and no instance can be discovered of an explosion happening to a range boiler provided with a safety-valve. And, considering that explosions with boilers of this kind are frequent enough to appear like an epidemic in some winters, it is saying much for the safety-valve as a life-saving appliance. Very many instances are known of safety-valves having averted explosions, as the conditions have clearly shown.

As to the causes of explosions with kitchen-range boilers of the high-pressure kind (bath or circulating boilers), they number four. Precedence is taken by frost, and the others, though real sources of danger, are rarely heard of. All the explosions, or, rather, the public attention to explosions, seem confined to the winter months; a hard winter usually giving a high record, a mild winter few or none. It is that the frost bites the two pipes of the hot-water apparatus that insure safety under ordinary conditions, the frost solidly choking them, whereas they would otherwise give relief to any strain that might be manifested. These are the expansion (steam-escape) and cold-supply pipes, which exist in every hot-water apparatus. Taking either of the two forms of apparatus illustrated by Figs. 21 and 22, the tank and the cylinder systems, *a* is

the expansion pipe, *b* the cold-supply service. As a rule, the cold-water cistern is in a very cold, perhaps exposed, place, and it is difficult to get the two pipes referred to in frost-proof positions at all points. The cold-supply surface is full of water everywhere, and the expansion pipe is full to the level of the water in the cistern, and, as a rule, the freezing occurs in these somewhere close up by the cistern, as the degree of cold is greatest there. Sometimes it is the pipes lower down that have their contents frozen and solidified, but it is not usual, as they run through different parts of the house where there is more or less warmth, sufficient to keep the water in a liquid state. If a house was vacated for a day or two during a frost, the family spending Christmas away from home, for instance, and no fire was lighted, there would most probably be frost-bites at different points, and no telling where.

It will be seen that if pipes are stopped by ice in this way, the stoppage is a very sound one, extending perhaps for two or three or more feet, and some destructive happening must occur, if a fire is lighted at the boiler under these conditions. There is no room for expansion, and if steam can be generated there gathers a force that is practically irresistible. If nothing transpires to avert the danger, an explosion ultimately occurs, and its terrible nature is due to the force having to be strong enough to burst a boiler which can probably stand 150 lb. pressure to the square inch, before the rupture takes place. The force is, therefore, as great as when a steam-boiler explodes, and everything near is shattered. When we read that kitchen-walls are blown out, we know the force is of decided magnitude.

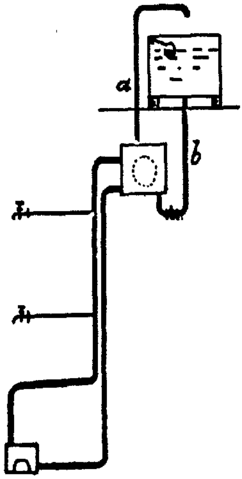

FIG. 21.

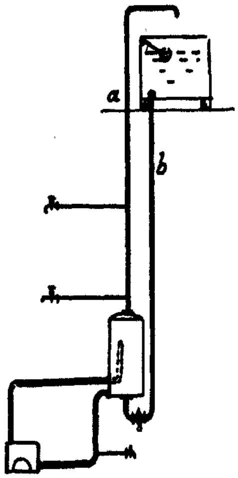

FIG. 22.

That kitchen boilers do explode under the conditions named (and no one denies this) is quite settled; but the reason of the explosion is the subject of debate sometimes. It is

argued, and with a deal of truth, that a boiler and pipes, if full of water, cannot explode. There may be a rupture, probably at the boiler, due to the expansion of the water when heated; but all parts being full of water, leaves no room for steam generation, and the explosive rending force of steam must be absent. The boiler or any weak part would sp'it open (the same as when the water expands by being changed into ice); but this action would be nearly silent, and the chief noticeable feature would be the escaping water. This is very feasible; but, if correct, why do explosions occur under just these conditions? The writer favours the theory just explained, but to account for the explosions, considers that while the water is heating up, a tap may be opened, and the water that issues makes room for steam generation.

Servants are always applying to taps, and this should be an element of safety, and doubtless is, in the usual way, for on applying to a tap when the conditions were so unusual, means that something equally unusual must be noticed there. Very little water would issue, and if any strain was being exerted, there would be no mistaking the symptoms. Under these circumstances the most ignorant of servants would probably report matters, and the fire would be extinguished. Servants applying to taps have doubtless averted many an explosion in this way, for apart from the odd results the taps may give, an open tap instantly relieves the strain, and delays the danger at least. Still explosions do occur, but doubtless in no greater number than 5 per cent. of the instances where they *might* have occurred, and in this 5 per cent. of cases it is practically certain that something transpired to make room for steam generation.

A very large percentage of the accidents, also the risks which do not happen to be attended by accidents, could be avoided by adopting measures to keep the frost from the water in the pipes. It is only necessary to do what we take care to adopt for the protection of our bodies when cold weather comes. We put clothing on better adapted to keep the effects of the cold away. It is hardly necessary to point out that the effects of suitable clothing is to prevent loss of heat from the body, to conserve it, and that clothes afford no warmth of themselves. Putting thicker clothing on makes us feel warmer by preventing the extraction or loss of heat. With water-pipes we can get excellent results by covering them with material to prevent loss of heat, to keep them at their normal warmth, although the air temperature is very low. Hair felt, wound on in strips, is excellent; but one thickness, though better than nothing, is not sufficient. For real efficacy it should be put on ¾ in. thick, then bound round with canvas. Incasing the pipes and packing the case tight with silicate cotton is also good, or any efficient means to prevent loss of heat. This need only be done where it is thought (or known) frost has sharp effect. Any pipes in a cistern room, attic, or roof should certainly be protected, but a real gain, summer or winter, will result by covering all pipes in this way from top to bottom of the house.

Sometimes provision is made to empty all pipes in a house, hot and cold, during the hours of night, or if the house is vacated for a day. Empty pipes are quite safe from the effects of frost, of course; but this measure involves trouble, waste of water (a great fault when the water has to be pumped by hand daily), and it introduces a new risk. The risk is in the servants, or others, omitting to recharge the hot-water apparatus before lighting the fire each morning. It is better to keep the frost away from the water, and this is quite possible. Another plan, adopted largely during the severe and prolonged frost of last winter, is to keep a little source of heat at the exposed points. Even night-lights have been put to this use, and it is sometimes quite

astonishing what a little heat will defy the frost.

The next source of danger with these boilers is shortness of water. The writer knows that a North of England association of boiler users have stated that an empty red-hot boiler cannot be exploded by a sudden inflow of water into it; but he holds a different opinion in regard to range boilers. The statement in question was the outcome of experiments made with a boiler which, when at a red heat, had water flow into it, and the boiler had a ¾-in. open hole which was supposed to correspond with the open pipes which a boiler would have under ordinary conditions. The results of trials was that the ¾-in. hole gave relief every time, although the generation of steam by water suddenly entering a red-hot boiler was little short of terrific in the force manifested. Since that time the writer has made the same experiment with an ordinary saddle boiler, having only a ⅜-in. hole in it, and still no explosion resulted. Notwithstanding this, for want of better practical proof, which can only be had with a boiler attached to an apparatus, and the apparatus in a suitable state, an empty boiler should still be considered a grave and very real risk.

It may not happen that every red-hot empty boiler explodes if water suddenly enters it; but supposing the open pipes (?) are badly furred, as thousands are, and there are ever so many twists and turns to these pipes, and every bend has a little extra collection of hard or loose fur, as they will have. Then one of the pipes is not open when water flows in the boiler, for a pipe full of water cannot be called an open pipe as regards relieving instantaneous steam pressure. Supposing all this, and it is all reasonable, and there is a fire in use against an empty boiler, making it red or nearly white hot. A thaw sets in, and the first indication we get is that the water runs in the pipes, water comes down in the boiler unexpectedly, and very little imaginative power is required to judge what happens in the boiler. The generation of steam can only be described as terrific, and it happens in such a brief instant of time that the pipes, as described, are undoubtedly useless to relieve the strain.

In a large London residence it happened (while the family were away) that an apparatus was emptied, and it was not refilled before the fire was lighted. The fire had been going nearly three hours before this was remembered, and for reasons best known to herself the housekeeper went at once and opened the cold supply stop-cock just as a good fire was going. No one was hurt, as the boiler was fitted with a safety-valve; but this valve gave evidence of a force that it was never prepared to withstand, as its cap of cast brass, screwed on, was blown out and curled up like a piece of paper. This meant a force greater than a half-choked ramification of pipes would relieve. As further evidence, a newspaper report of last winter gave an instance of a boiler exploding at Norwood (two deaths), and the cause was clearly stated as working with a red-hot empty boiler which water was allowed to enter while in that state. There was no reason for supposing this was a mistaken diagnosis. Further than this, the writer has noticed that explosions have occurred at the times that a thaw first sets in, and this speaks volumes.

In any case it is the height of imprudence to run this risk. The year before last cases were met with of fires being kept going after the water failed, the users supposing the only risk to be that a new boiler might be necessary. A large house cannot do without its kitchen fire for a lengthened period, so it is lighted against the empty boiler, and if sufficient care is taken that no water can possibly enter the boiler unexpectedly, then the risks are reduced to the possible burning and fracture of the boiler only. The unfortunate part of the statement that a red-hot empty boiler cannot be made to explode is that a certain type

of workman can now be met with quoting this statement, and acting in a heedless way in consequence. Time will show who is right.

A further source of danger is the use of stop-cocks in the main circulating pipes. They are seldom fixed in this position; but when they are, their use is to enable a workman to open the boiler without employing the tank or cylinder, thus saving both time and water. The last accident recorded from this cause took the hot-water fitter's life for a sacrifice. He had cleaned out the boiler, closed it, and lighted the fire to see all went well. He had not opened the cocks, and there was a little drop of water left in the boiler as usual, sufficient to make the steam required to burst it.

The final cause of explosions is a possible, but improbable, one. This is incrusted deposit, or fur, which could stop the pipes and seal the boiler if ever allowed to do so. It is doubtful if an explosion has ever happened from this cause; but if it were not that the trouble gives unmistakable warning of its growth, it would excel frost in the number of explosions it might bring about. As a rule, it is only one of the two pipes from a boiler that gets furred badly; but it would be quite possible for the second one to get as bad, if the first one could be borne with long enough. It is the flow-pipe that, with rare exceptions, furs up the quickest, and when the passage through it is reduced from one-half to three-fourths, the warning comes in the character of alarming noises, accompanied by vibration or shock. This is sometimes borne for a while in a busy house; but before this single pipe gets quite closed, the violence of the phenomena is past bearing, frightening the servants, and making an engineer's attendance imperative.

As stated in the first few lines, the safety-valve can at present be considered a universal remedy. Even if a failure should presently be recorded, it could only be owing to some very irregular condition, and the valve could not be called any the less a safety appliance. Their compulsory use will probably come sooner or later; but, as it is, the public want very little pressing to spend the small sum necessary to be provided with one. The records of the few past winters make the sale of safety-valves rather an easy task, and in the autumn season many tradesmen should be doing a busy trade in them

LABELS.
(SECURING AND PRESERVING.)

(*See also* TRANSFERS.)

Securing Labels. *To Fasten Paper Labels on Polished Nickel or Silver.*—Dissolve 40 parts by weight of coarsely powdered dextrin in 60 parts of water, add 2 parts of glycerine and 1 part of glucose. Heat the mixture to 194° F.

To Fasten Paper Labels to Iron.—Rub the spot where the label is to come with the cut surface of half an onion, then fasten the label on with paste, gum, or glue. The label will adhere firmly and stand some heating.

To Fasten Paper Labels on Tin.—Among others, the following methods have been suggested for this purpose: The addition of about 3 or 4 per cent. aluminium sulphate (not alum), or better still, about 10 per cent. of butter of antimony, is said to greatly improve the adhesiveness of mucilage. Others have suggested roughening the surface with acids or adding substances to the mucilage which yield acids in small degree on applying to the tin; thus, honey, flour, treacle, etc., have come into use as seen in formula No. 1.

1. Make gum tragacanth into mucilage of the desired consistence with hot water, and then add to it 10 per cent. of flour.

2. Boil 2 lb. of flour with 1 qt. of water to make a stiff paste; add 2 oz. of tartaric acid and 1 pint of molasses. Boil together until stiff, and add 10 drops of carbolic acid.

3. Shellac, 2 parts; borax, 1 part; water, 16 parts, are boiled together until the shellac dissolves.

4. Add 1 oz. of dammar varnish to 4 oz. of tragacanth paste.

5. Roughen the surface with emery paper, then apply the label preferably with water-glass as an adhesive agent.

6. Balsam of fir, 1 part; turpentine 3 parts. Dissolve. This is only applicable with good qualities of well-sized labels.

7. Clean the surface by rubbing with solution of caustic potash, and then thoroughly wipe before applying the label. This is employed on the principle of attributing the difficulty to the presence of a thin film of grease, as is also the case with the addition of water of ammonia to the paste.

8. Brush the surface over with a thin coat of butter of antimony or with oleate of mercury, clean well and apply the label.

9. Brush over with strong tannin solution, allow to dry, and apply the label, previously well gummed.

10. Add Venice turpentine to good starch paste.

11. Soften glue with water and then dissolve it in acetic acid to 10 per cent. strength.

12. About 15 per cent. of glycerine added to the paste is said to work admirably.

Paste for Fastening Paper upon Tin-foil, etc.—Dissolve rye-flour in a solution of caustic soda to a paste, and dilute the latter with well-water, stirring constantly. Then heat Venetian turpentine and add this to the paste, a few drops being sufficient for ½ lb. of flour. This paste adheres firmly to all metals, tin-foil, glass, etc.

To Fasten Labels on Metal.—The following composition is recommended:—

Mucilage of tragacanth	10	parts.
Honey . . .	10	,,
Flour	1	,,

To Fasten Paper Labels to Tin, Zinc, or Glass.—Water-glass (solution of silicate of soda) is recommended as a very good adhesive for this purpose, particularly if the articles are subsequently liable to be exposed to heat. Metallic surfaces should first be rubbed with emery paper before applying the paste; the label is then pressed on with the hand. ('Drog. Zeit.')

To Fasten Paper Labels to Bottles and Glass.—(1) Ordinary glazed paper, preferably of a citron-yellow colour, is wiped over with a damp sponge, and then again allowed to dry. The ink used for writing the labels is prepared

from 3 parts extract of logwood and 1 of bichromate of potassium, dissolved in 30 of water. After standing until it has become clear, the liquid is decanted from the sediment, and 2 parts gum arabic are then added. When the writing has become dry, the label is affixed to the receptacle by means of a glue-paste, prepared by pouring a boiling solution of carpenters' glue into a cold prepared paste made from wheat-flour and water. When the label has become dry, it is brushed over twice with the same glue-paste, the second application being delayed until the first is dry. Finally the label is varnished over with dammar varnish containing 10 per cent. of Canada balsam. (R. Triest.)

(2) Affix a common paper label and let it dry; then heat the label (by a Bunsen burner of very small flame) till it will just melt paraffin rubbed on it. The label is absolutely protected, and looks as if it were enamelled on the glass. If the neck and lip of the bottle and the stopper are similarly treated, a perfect airtight joint is secured and the stopper never sets, while liquids can be poured out without running down the sides.

(3) Brush the paper labels with thin size, and afterwards with the ordinary photographers' spirit varnish, or with common white hard varnish, applied before the fire. Or you can paint the name direct on the glass with Bate's black (a superior kind of Brunswick black), sold by the photo dealers. A simple waterproof cement for labels is made by stirring linseed-oil into hot glue, 1 part oil to 3 or 4 of glue, which should, of course, be previously soaked and dissolved in water to about the consistence used by carpenters.

(4) Paper labels, attached in the usual manner, and, when dry, varnished over with 2 or 3 coats of good copal varnish, will be found to resist almost all chemicals except liquor potassæ and liquor sodæ.

(5) When, as will sometimes occur in sudden change of weather, or from age, glass bottle-labels drop off, leaving the resinous layer, together with the lettering, adherent to the bottle, they may again be fastened by painting the glass and label with concentrated solution of white shellac, and holding the glass in place for a few days by means of an elastic band.

Flour Paste.—The ordinary flour paste, which is so useful and effective for fastening paper on paper or on many other substances cannot be perfectly made unless the exact process is known. It is simple, yet if not followed exactly the paste will be absolutely useless. It should be made as follows: For about 1 pint put 2½ to 3 heaped tablespoonfuls of ordinary wheat flour into a full-sized basin. Add cold or just warm (not hot) water to this very slowly, stirring briskly all the time, until the whole is of the consistence of thick mustard. Beat and rub well with the spoon to make sure all lumps are smoothed out. Now take a kettle of boiling water (it must be quite boiling) and pour a thin stream on the mixture, stirring well all the time. At first the addition of the hot water will thin the mixture, and the thought will occur that the result can only be some thin flour and water, not paste. After the pouring has been continued, however, until the whole is about a pint (perhaps a little less), the mixture will be found to quickly thicken and become rather stiff. If now allowed to cool, it will become like a thick jelly. The writer's practice is not to be quite satisfied with the paste so obtained, but so soon as it thickens (when the boiling water is being poured in), to then put the mixture on the hot plate and heat it a little when it thickens still more. There is no doubt that the thickening is due to a cooking process, effected by the boiling water, which process can be continued and perfected by heating the paste still further, on a hot plate, for about 3 to 5 minutes, stirring all the time. To do this, the writer makes the mixture, from the beginning, in a saucepan instead of a basin.

Starch Paste.—This is a very

adhesive paste and is suited for many special purposes as having no acidity. It is largely used for labelling delicate specimens, also for mounting photographic prints.

The raw material is pure starch sold by the chemist as a fine white powder. It keeps for any length of time in a stoppered bottle. The grocer's lump starch is not reliable; it is not always the same, and hence there is difficulty in getting the starch to jellify properly, which will not occur if the pure starch is used. Place a spoonful or so of the powder in a dry cup, and add very gently enough water to make a very stiff paste. A fork is better than a spoon as a mixer, and the water and powder should be intimately mingled into a smooth mixture, so stiff that one has to exert some force to move the fork in it. Anything as thin as ordinary cream, or fluid enough to run when the cup is inverted, is not so good in preparing a fine mountant free from lumps. Now get ready some absolutely boiling water. Lift the vessel straight off the fire or gas, and pour a thin stream into the starch, stirring briskly with the fork. The starch will gelatinise or "jellify," becoming semi-transparent. Add the water until the mixture is rather thinner than you would care to use it when cold, and stand aside to cool. The contents should not be stirred up during cooling. As soon as the mass has fallen to the ordinary temperature, a skin will be seen on the surface of the paste. Take this off with a spoon, and the mountant is ready for use.

Label Paste.—A good strong paste is made by soaking glue in vinegar, then heating it to boiling point and adding flour to a suitable thickness. It does not decompose and is very adhesive.

Label Varnish.—(1) One of the best label varnishes is the following:—

Sandarac (in coarse powder)	100 parts
Mastic " "	40 "
Copaiba	15 "
Venice turpentine . .	30 "
Oil of turpentine . .	40 parts
Alcohol	90 "
Absolute alcohol . .	90 "

Macerate until solution is effected.

(2) Best.—8 lb. Manilla copal, 8 lb. French rosin, 2 gallons methylated spirit. Common.—Manilla copal, 11 lb.; French rosin, 17 lb.; methylated spirit, 2 gallons; castor-oil, ½ oz.

Preservation of Labels.—(1) For paper labels a thick celluloid varnish is recommended, this being a solution of celluloid in amylacetate, as used by photographers. No previous sizing is needed, and when the solvent has evaporated, the white surface of the paper is left unaltered. It is used in the Oxford University laboratory.

(2) *Wooden Labels.*—Thoroughly soak the pieces of wood in a strong solution of sulphate of iron; then lay them, after they are dry, in lime-water. This causes the formation of sulphate of lime, a very insoluble salt, in the wood. The rapid destruction of the labels by the weather is thus prevented. Bast, mats, twine, and other substances used in tying or covering up trees and plants, when treated in the same manner, are similarly preserved. Wooden labels, thus treated, have been constantly exposed to the weather during two years without being affected thereby.

Writing on Glass.—Warm the glass to 120°–140° F., until vapour is no longer deposited. Then bathe the surface with the following varnish, moving the plate as when applying collodion in photographic work. The varnish consists of 80 grams 95 per cent. alcohol, 5 grams mastic in sheets, and 8 grams dammar. The solution is made in a firmly corked bottle on the water-bath, and then filtered. This varnish is very hard, brilliant and transparent. Drawings in common or Indian ink can be made on this surface; after completion, a thin layer of gum is added. This method can be used for marking bottles, designs for projecting on a screen, or for photographic purposes.

Etching on Glass.—A fluid has recently been introduced into commerce, and can be used with an ordinary pen. It consists of hydrofluoric acid, ammonium fluoride, and oxalic acid, and is thickened with barium sulphate. A better ink is obtained as follows: Equal parts of the double hydrogen ammonium fluoride and dried precipitated barium sulphate are ground together in a porcelain mortar. The mixture is then treated in a platinum, lead, or gutta-percha dish with fuming hydrofluoric acid, until the latter ceases to react. ('Dingl. Polyt.')

Plant Labels.—(1) In transplanting spring shoots, as well as in sowing seeds, the gardener often feels the need of a convenient label, that will withstand the rain and not get soiled with the mud. A writer in the German 'Diamond' recommends the use of glass tubes, in which the paper labels can be slipped, and the tube corked or sealed. The tubes should be 8 in. long and have an interior diameter of ½ in., and be made of quite thick glass. For house plants and conservatories, elegant labels can be made from wider and shorter tubes, open at both ends, one being closed with a cork, from which the label is suspended by a thread or wire passed through the cork, the other end being used to hang the tube on a branch of the tree or shrub.

Writing on Metals.—Take 1 lb. nitric acid and 1 oz. muriatic acid. Mix and shake well together, and it is ready for use. Cover the plate you wish to mark with melted beeswax; when cold, write your inscription plainly in the wax clear to the metal with a sharp instrument. Then apply the mixed acids with a feather, carefully filling each letter. Let it remain 1–10 hours, according to the appearance desired, throw on water, which stops the process, and remove the wax.

Removal of Encaustic Letters.—The signatures, letters, numbers, etc., upon porcelain vessels may be removed without injury to the glazing, by protracted polishing with a piece of pumice moistened with concentrated hydrochloric acid. The removal is facilitated by previously exposing the signatures to the vapours of hydrochloric acid.

LABORATORY APPARATUS.

(*And see* CEMENTS, DISTILLING AND DRYING AND EVAPORATING.)

Wire Apparatus for Laboratory Use. It is my purpose to bring to the notice of the reader several new as well as some well-known forms of laboratory appliances made of wire; and while I am conscious that this subject is by no means exhausted, I believe that the few examples of wire apparatus for the laboratory given in Figs. 23 and 24 will not only be found useful, but will prove suggestive of other things equally as good. I have found wire invaluable for these and kindred purposes, and have often made pieces of apparatus in the time that would be required to order or send for them, thus saving a great deal of time, to say nothing of expense, which is no considerable item in matters of this sort.

It is perhaps unnecessary to describe fully in detail each article represented, as an explanation of the manipulations required in forming a single piece will apply to many of the others.

For most of the apparatus shown, some unoxidisable wire should be selected, such as brass or tinned iron, and the tools for forming these articles of wire consist of a pair of cutting pliers, a pair of flat and a pair of round-nosed pliers, a few cylindrical mandrels of wood or metal, made in different sizes, and a small bench vice. Any or all of the articles may be made in different sizes, and of different sizes of wire for different purposes.

A shows a pair of hinged tongs, which are useful for handling coals about the furnace, for holding a coal or piece of pumice for blowpipe work, and for holding large test tubes and flasks, when provided with two notched corks, as shown in B and O. These tongs are made by first winding the wire of one half around the wire of the other half to form the joint, then bending each part at right angles, forming on one end of each half a handle, and upon the other end a ring. By changing the form of the ring end the tongs are adapted to handling crucibles and cupels and other things in a muffle.

C shows a pair of spring tongs, the construction of which will be fully understood without explanation. It may be said, however, that the circular spring at the handle end is formed by wrapping the wire around any round object held in the vice; the rings at the opposite end are formed in the same way. The best way to form good curves in the wires is to bend them around some suitable mandrel or form.

D shows a spring clamp for holding work to be soldered or cemented. It may also be used as a pinch cock.

E represents a pair of tweezers, which should be made of good spring wire flattened at the ends. F is the clamp for mounting microscope slides, and for holding small objects to be cemented or soldered. G is a pinch cock for rubber tubing; its normal position is closed, as in the engraving, but the end *a* is capable of engaging the loop *b*, so as to hold the pinch cock open. H shows a clamp or pinch cock having a wire *c* hooked into an eye in one side, and extending through an eye formed in the other side. This wire is bent at right angles at its outer end to engage a spiral *d*, placed on it and acting as a screw. The open spiral is readily formed by wrapping two wires parallel to each other on the same mandrel, and then unscrewing one from the other. The handle will of course be formed by aid of pliers. I shows still another form of pinch cock. It is provided with two thumb-pieces, which are pressed when it is desired to open the jaws. K is a tripod stand, formed by twisting 3 wires together. This stand is used for supporting various articles, such as a sand bath or evaporating dish, over a gas flame. It is also useful in supporting charcoal in blowpipe work.

L shows a stand adjustable as to height for supporting the beak of a retort, or for holding glass conducting or condensing tubes in an inclined posi-

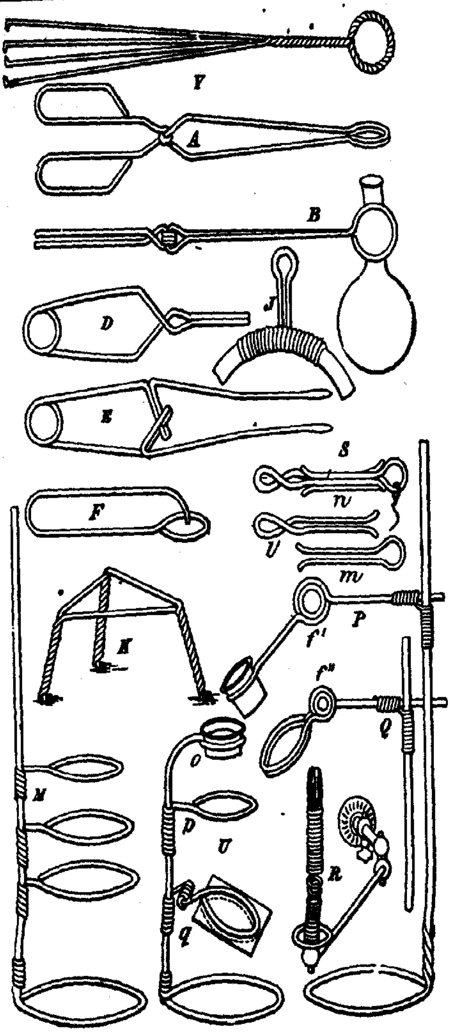

FIG. 23

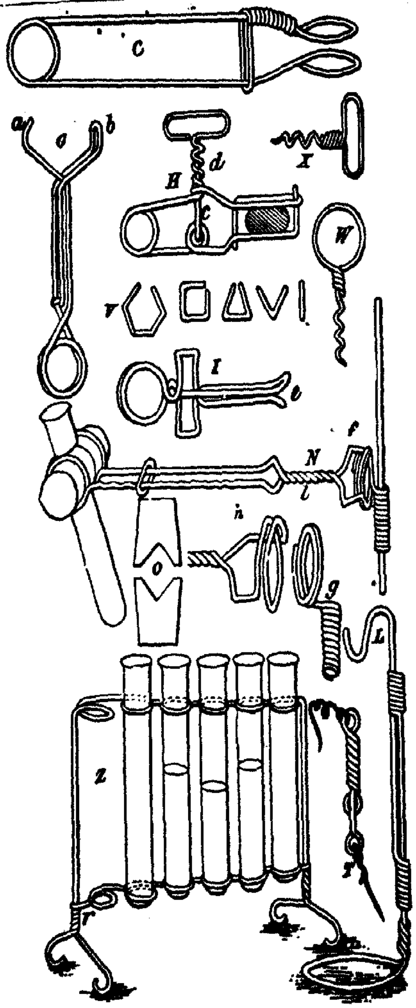

FIG 24

tion. The retort or filter stand, represented in M, is shown clearly enough to require no explanation. Should the friction of the spiral on the standard ever become so slight as to permit the rings to slip down, the spirals may be bent laterally, so as to spring tightly against the standard. N shows an adjustable test tube holder, adapted to the standard shown in M, and capable of being turned on a peculiar joint, so as to place the tube in any desired angle. The holder consists of a pair of spring tongs, having eyes for receiving the notched cork, as shown in O. One arm of the tongs is corrugated to retain the clamping ring in any position along the length of the tongs. The construction of the joint by which the tongs are supported from the slide on the standard is clearly shown in O *a*. It consists of two spirals *g h*, the spiral *h* being made larger than the spiral *g*, and screwed over it, as shown in O. This holder is very light, strong and convenient.

P represents a holder for a magnifier, which has a point f^1, similar to the one just described. The slide *k* is formed of a spiral bent at right angles and offset to admit of the two straight wires passing each other. This holder may be used to advantage by engravers and draughtsmen. Q shows a holder for a microscope condenser, the difference between this and P being that the ring is made double to receive an unmounted lens.

R shows a Bunsen burner, formed of a common burner, having a surrounding tube made of wire wound in a spiral, and drawn apart near the top of the burner to admit the air, which mingles with the gas before it is consumed at the upper end of the spiral.

S represents a connector for electrical wires, which explains itself. The part with a double loop may be attached to a fixed object by means of a screw. Another electrical connector is shown in T, one part of which consists of a spiral having an eye formed at each end for receiving the screws which fasten it to its support, the other part is simply a straight wire having an eye at one end. The connection is made by inserting the straight end in the spiral. To increase the friction of the two parts, either of them may be curved more or less.

A microscope stand is shown in U. The magnifier is supported in the ring *o*. The ring *p* supports the slide, and the double ring *q* receives a piece of looking-glass or polished metal, which serves as a reflector.

V shows a set of aluminium grain weights in common use. The straight wire is a 1 gr. weight, the one with a single bend is a 2 gr. weight, the one having two bends and forming a triangle is a 3 gr. weight, and so on. W and X are articles now literally turned out by the million. It is a great convenience to have one of these inexpensive little corkscrews in every cork that is drawn occasionally, thus saving the trouble of frequently inserting and removing the corkscrew. The cork puller shown in Y is old and well known, but none the less useful for removing corks that have been pushed into the bottle, and for holding a cloth or sponge for cleaning tubes, flasks, etc.

Z shows a stand for test tubes. The wire is formed into series of loops, and twisted together at *r* to form legs. A very useful support for flexible tubes is shown in J. It consists of a wire formed into a loop, and having its ends bent in opposite directions to form spirals. A rubber tube supported by this device cannot bend so short as to injure it. Most of the articles described above may be made to the best advantage from tinned wire, as it possesses sufficient stiffness to spring well, and at the same time is not so stiff as to prevent it from being bent into almost any desired form. Besides this the tin coating protects the wire from corrosion, and gives it a good appearance. (Geo. M. Hopkins.)

Liebig Condenser.—This condenser (Fig. 25) is much more compact, and is equally as effective as the ordinary form. Much valuable space is saved, which the chemist may use to

better advantage. *a* is a tube about 2½ in. diameter, and 20–24 in. long. *b* is a tube 1½ in. diameter, closed at the upper end. This tube is fitted to the large tube by a thick heavy cork soaked in melted paraffin. The tube *e*, which reaches nearly to the bottom of the condenser, serves as an inlet for cold water, and *f* the outlet for the heated water. The tube *c*, connected with the flask *g*, carries the hot vapours to the condenser, where they are condensed and delivered by the tube *d* to any suitable receiver. The tube *c*, which is connected with a cork to the condenser, should pass up 2–3 in. beyond the cork to prevent the condensed vapours from passing back into the retort flask.

If properly constructed this condenser is very effective. Very little trouble will be experienced by the vapours condensing in *c*, and running back; so little surface is exposed to the cold atmosphere and cork connection. The vapours condensing in *b* run down the walls of the tube, and are completely delivered by the smaller tube *d*.

This condenser is admirably adapted for the distillation of nearly all liquids of low boiling-points, which do not form explosive vapours, to come in contact with the flame under the flask *g*. However, highly volatile liquids like the ethers may be safely distilled by screening the receiver from the heat of the flame, and by connecting with the receiver a safety tube delivering the vapours escaping out of a window, or through a partition into an adjoining room.

I usually employ as a safety connection, in the distillation of highly

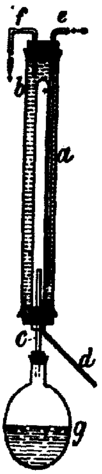

FIG. 25.

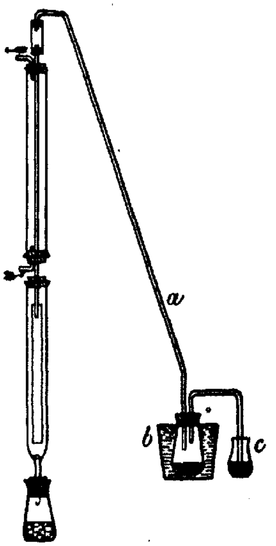

FIG. 26.

volatile and combustible liquids, a tube connected with the receiver, the extreme end of which dips under mercury, covered with a layer, 1 in. deep, of oil of a suitable character. This arrangement I have found perfectly safe; any escaping vapours are absorbed by the oil. (Chas. B. Gibson.)

Safety Valve for Extraction Apparatus (Fig. 26).—Used very successfully when it is desirable to run the extraction for some hours, at the same time the attention being devoted to other work. The tube *a* is connected with the Liebig as shown, and with the flask *b*, which is loaded with mercury, and immersed in a vessel of cold water. Another tube passes from *b* into *c*, which is partly filled with mercury and oil. This apparatus is perfectly safe, as any vapours of the ether or benzine, which may not become condensed in the Liebig and flask *b*, will surely be absorbed by the oil in *c*. I have run this apparatus continuously for 24 hours, and have scarcely been able to detect even the smell of ether at *c*. I have no fear of accidents, even with high heat from a Bunsen burner, when these precautions are taken. (Chas B. Gibson.)

Wash-bottle. — By this simple device (Fig. 27) the washing of precipitates and the cleansing of vessels used in the process of analysis, which before required the use of the ordinary wash-bottle, can now be done with much more facility and in a shorter time. It consists essentially of a thin glass flask C, placed about 3 ft. above the level of the working desk, and closed by a 3 hole rubber stopper. Through one of the holes issues a rubber tube D (or glass with rubber connections), descending to the desk and ending in a glass nozzle. Connection is made by a second hole in the stopper with a reservoir bottle A, placed above the top of the wash-bottle. In the third hole is placed a glass tube bent at an angle to keep out dust. On filling the flask from the reservoir—the flow being stopped by a pinch cock—the water is started by suction from below, and the stream through the nozzle can be regulated or stopped at will by a pinch cock placed conveniently to the hand, the height of the water flask furnishing the pressure, which is sustained by the syphon.

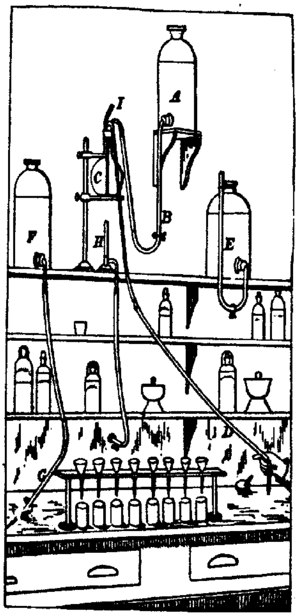

FIG. 27.

A Bunsen burner H is placed underneath the flask, and the water can be heated when it is so desired. Hot water as well as cold can thus be used in treating precipitates. Other solutions can be employed equally as well as water. (See bottle F.)

The advantages of this system are :—

1. The saving of much time and consequent labour attending the use of an ordinary wash-bottle, especially where several analyses are carried on at the same time, the exertions required by the mouth and lungs being thereby avoided.

2. No air exists in the tube, as in an ordinary wash-bottle, and consequently the full force of the liquid is utilised immediately.

3. When used with a wash solution of ammonia water, no trouble is experienced with free ammonia, which ordinarily is quite hurtful to the mouth and eyes.

The large bottle E with the accompanying tube shows a convenient arrangement for holding any solution and delivering the same. (H. B. Battle.)

Water-Bath, Percolator, and Still Combined.—Figs. 28–30, show Fenner's combined apparatus which can be used as a water-bath, a percolator, a still, and evaporator, for making tinctures, fluid extracts, solid extracts, infusions, syrups, etc., and for distilling, evaporating, etc.

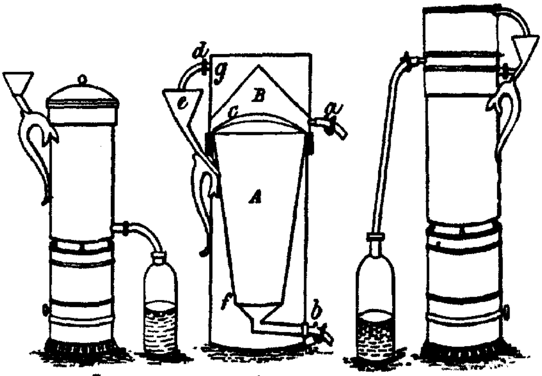

FIG. 28. FIG. 29. FIG. 30

An Acid-proof Paint for Laboratory Tables and Benches, etc.—Three or four years ago the writer saw in a pharmaceutical journal (Merck's 'Report') a formula for a black finish for table tops. The article did not give the author's name nor the original source of the formula, but stated that the method was "used abroad." Further acknowledgment cannot, therefore, be made. The formula was as follows:—

1. Copper sulphate . .	1 part
Potassium chlorate .	1 part
Water	8 parts

Boil until salts are dissolved.

2. Aniline hydrochlorate .	3 parts
Water	20 „

Or if more readily procurable:—

Aniline	6 parts
Hydrochloric acid . . .	8 „
Water	50 „

By the use of a brush two coats of solution No. 1 are applied while hot; the second coat as soon as the first is dry. Then two coats of solution No. 2, and the wood allowed to dry thoroughly. Later a coat of raw linseed-oil is to be applied, using a cloth instead of a brush, in order to get a thinner coat of the oil.

The writer used this method upon some old laboratory tables which had been finished in the usual way, the wood having been filled, oiled, and varnished. After scraping off the varnish down to the wood, the solu-

tions were applied, and the result was very satisfactory.

After some experimentation, the formula was modified without materially affecting the cost, and apparently increasing the resistance of the wood to the action of strong acids and alkalies. The modified formula follows:—

1. Iron sulphate	4	parts
Copper sulphate	4	,,
Potassium permanganate	8	,,
Water, q.s.	100	,,
2. Aniline	12	parts
Hydrochloric acid	18	,,
Water, q.s.	100	,,
or		
Aniline hydrochlorate	15	,,
Water, q.s.	100	,,

Solution 2 has not been changed, except to arrange the parts per hundred.

The method of application is the same, except that after solution No. 1 has dried the excess of the solution which has dried upon the surface of the wood is thoroughly rubbed off before the application of solution No. 2. The black colour does not appear at once, but usually requires a few hours before becoming ebony-black. The linseed-oil may be diluted with turpentine without disadvantage, and after a few applications the surface will take on a dull and not displeasing polish. The table tops are easily cleaned by washing with water or suds after a course of work is completed, and the application of another coat of oil puts them in excellent order for another course of work. Strong acids or alkalies when spilled, if soon wiped off, have scarcely a perceptible effect.

A slate or tile top is expensive not only in its original cost, but also as a destroyer of glassware. Wood tops when painted, oiled, or paraffined, have objectionable features, the latter especially in warm weather. Old table tops after the paint or oil is scraped off down to the wood take the above finish nearly as well as the new wood. (Pierre A. Fish, in the 'American Journal of Applied Microscopy.')

LACQUERS AND LACQUERING.

(*See also* BRONZING, JAPANS AND JAPANNING, *and* PAPIER MACHÉ.)

WHEN properly lacquered, brass work will retain its colour, and resist the action of the atmosphere for a long time; hence the necessity of always lacquering work which should retain a good appearance. The process is rather difficult to execute on large surfaces, where the amateur will find the lacquer continually getting a smeary look. Before applying the lacquer, the brass must be heated to a certain degree, and the difficulty is to know the exact degree best suited to the particular lacquers and materials used, and the effect to be produced; but for general trade purposes the heat of boiling water (212° F.) is ordinarily worked to.

A camel-hair brush is used to lay on the lacquer with, after the articles are heated; be careful not to touch the bright surface with anything that will stain it, and lay on the lacquer as thinly as possible to prevent smears. If the work is too hot it will burn the lacquer, and if too cold it will not set hard. Small thin articles part with a large proportion of their heat in laying on the lacquer, but bulky work is comparatively unaffected; so small articles must be made somewhat hotter than large before lacquering. Only experience will enable anyone to judge correctly.

Lacquer is so called because it contains gum lac, either shellac or seed lac. Seed lac is the original form of the gum or resin; after being purified it is moulded into thin sheets, like shell, and hence is called shellac. Shellac is frequently bleached so as to become quite white, in which state it forms a colourless solution. Bleached shellac is never as strong as the gum in its natural condition, and unless it be fresh it neither dissolves well in alcohol nor does it preserve any metal to which

it may be applied. There are many recipes for good lacquer, but the success of the operator depends quite as much upon skill as upon the particular recipe employed. The metal must be cleaned perfectly from grease and dirt, and in lacquering new work it is always best to lacquer as soon after polishing as possible. Old lacquer may be removed with a strong hot solution of potash or soda, after which the work should be well washed in water, dried in fine beech or boxwood sawdust, and polished with whiting applied with a soft brush. The condition of the work, as to cleanliness and polish, is perhaps the most important point in lacquering. A temperature of about that of boiling water will be found right. The solution of lac or varnish is coloured to suit the requirements or taste of the user.

Brass.—In preparing brass for the colourless or nearly colourless lacquer, the goods, after being pickled and washed, are either dipped for an instant in pure commercial nitric acid, washed in clear water, and dried in sawdust; or immersed in a mixture of 1 part of nitric acid with 4 of water, till a white curd covers the surface, at which moment the goods are withdrawn, washed in clear water, and dried in sawdust. In the first case, the brass will be bright; in the latter, a dead flat, which is usually relieved by burnishing the prominent parts. Then the goods are dipped for an instant in commercial nitric acid, and well washed in water containing argol, to preserve the colour till lacquered, and dried in warm sawdust. This latter is not necessary, if the work is to be finished at once. So prepared, the goods are heated on a plate and varnished. The varnish used is one of spirit, consisting, in its simple form, of 1 oz. shellac dissolved in 1 pint alcohol. To this simple varnish are added such colouring substances as red sanders, dragon's blood, and annatto, for imparting richness of colour. To lower the tone of colour, turmeric, gamboge, saffron, Cape aloes, and sandarach are used. The first group reddens, the second yellows the varnish; while a mixture of the two gives a pleasing orange, and various tints can be got by suitable mixtures.

Small circular work, after being well scoured, and burnished (if necessary), is best lacquered in the lathe. The work should be slightly warmed over a clear charcoal fire, or in a stove, and the lacquer applied very thinly with a soft camel-hair brush. A charcoal brazier should be held under the work for a few seconds, after the application of the lacquer, to prevent chilling. To lacquer a flat surface, clean carefully by boiling in American potash and water. Dip in hydrochloric acid, if it be desirable to heighten the colour of the brass; wash well, first in cold water, then in hot (removing any black muddiness with a fine brush), and dry in hot sawdust. When dry, burnish if required. Place upon a flat iron plate, just lukewarm. Pass the lacquer quickly but evenly over the surface, by means of a rather large but fine camel-hair brush. Be careful not to pass twice over the same spot, or a ridge is almost sure to appear. Warm the lower plate until the work is quite dry.

In proceeding to work it is best to have the lacquer in a jar or pot with a stiff wire across the top, so that the brush can be drawn across it to take off surplus lacquer. This aids in getting the best quantity of material on the brush, but it is necessary to keep the wire clean or the brush may gather up thickened pieces. The metal work must not be made too hot or the lacquer will scorch or discolour. As a rule the heat can be judged by noticing when the sweat or vapour clears off. When a rich or thick effect is desired it is best to put on successive thin coats, warming between each, rather than applying a thick coat at once. The brush cannot be applied too lightly. For different classes of work there should be prepared suitable clips or holders, so that the work can be turned round, while held in the left hand, without fingering it. In

event of the work being made too hot and the lacquer becoming discoloured, it can be removed at once with spirit, or by the process adopted in re-lacquering (described later). As previously mentioned camel-hair brushes are used, and a good brush goes far towards producing good work. They are flat brushes, and when necessary an uneven edge can be trimmed, with a sharp knife, on a board. Should the brush be allowed to get hard, it can be softened by warming it and then dipping it in the fluid lacquer.

Re-lacquering.—As the name implies this process is to renew the surface of articles which have already received a coat of lacquer. It is work for which there is a large demand, as lacquered metal goods, if much used or exposed, become shabby and ill-looking. This effect, in the case of door-furniture and cheap domestic fittings, is hastened and largely due to poor quality of work in the first instance.

The first process is to remove the old lacquer, for re-lacquering on the top of old lacquer is never a success, even if the old surface is made to look clean first. For those who prefer making a pickle for this purpose, make a strong lye of wood ashes and strengthen this with soap lees. Boil the mixture and on putting in the goods the old lacquer will quickly come off. Wash in clean water and dry well. Have ready another dipping acid or pickle of aquafortis (commercial or common nitric acid) with water. Dip the goods in this, then immediately wash in clean water, dry well and rub bright with a leather. The lacquering is now done as with new goods.

An improvement on the plain nitric acid and water dipping bath is to mix together sulphuric acid (strong), 10 parts; red fuming nitrous acid, 5 parts; water, 5 parts. Mix in the open air, as a suffocating gas is given off. When fuming has ceased, the mixture can be stirred (using a wooden or glass stirrer) and is ready for use. This and similar dipping baths is to produce the gold-bright effect on the brass that is so desirable. It is an excellent mixture. As with other dipping acids the articles must be washed, dried, and finished as quickly as possible. Dipping acid, if left too long on the surface, or if the article is immersed in it too long, receive a dead or matt surface. This is sometimes desirable in instrument work.

For removing old lacquer, when nothing else is available, common washing soda may be used. Make a very strong solution, and boil the articles in this. It will take quite 1 hour's boiling, whereas with caustic soda about half this time will suffice. If time will admit, and it is convenient, the goods can be simply put into a hot strong solution of washing soda and left there all night, or, say, 12 hours. In each case the lacquer will be removed, or will come off very quickly with a brush. When the goods have become blackened in places (usually where the old lacquer is worn off), or, in fact, whenever the brass appears to be discoloured, the articles must be re-polished before they are dipped and lacquered. For the worst parts the finest emery cloth or flour emery may be used (though in some cases a smooth file has to do a part first), then follow with rotten-stone or crocus and oil. Next rub with a clean soft cloth to remove all oil, and finally rub over with dry powdered rotten-stone. When convenient, the surface may be burnished with advantage. This would be the case with round knobs if a lathe is available.

The Preparation of Dead or Matt Dip for Brass.—The dead dip is the one which is used to impart a satiny or crystalline finish to the surfaces of ornamental brass articles. The bright dip gives the smooth, shiny, and perfectly even surface, but the dead dip produces a surface which is most beautiful. When properly done there is just enough life to it to give a pleasing appearance, but yet not sufficient to give false light reflections like a highly-polished surface. It is by far

the most pleasing of any dip finishes, and can be used as a base for many secondary finishes.

Concisely speaking, the dead dip is a mixture of oil of vitriol (sulphuric acid) and aquafortis (nitric acid) in which there is enough sulphate of zinc (white vitriol) to saturate the solution. It is in the presence of the sulphate of zinc that the essential difference between the bright and the dead dip exists.* Without it the perfect dead or matt surface cannot be obtained.

The method generally practised in making up a dead dip is to add the sulphate of zinc to the mixed acids (sulphuric and nitric) so that some remains undissolved in the bottom of the vessel. At first thought this would seem satisfactory, but upon giving it further consideration it will be found that the sulphate of zinc occurs in small crystals having the appearance of very coarse granulated sugar. These crystals readily settle to the bottom of the vessel and do not do the work of matting which is required of them. If they are finely pulverised, the dip is slightly improved, but not as much as is frequently desired. It is impossible to pulverise such material to a fineness that will do the desired work. The use of sulphate of zinc, then, leaves much to be desired.

The most modern method of making up the dead dip is to produce the sulphate of zinc directly in the solution and in the precipitated form. It is well known that the most finely divided materials are those which are produced by precipitation, and in the dead dip it is very important that the sulphate of zinc which is in it shall be in a finely divided condition, so that it will not immediately settle to the bottom of the vessel. If the sulphate is precipitated as subsequently desired it will be produced in the very finest kind of a precipitate, so that when it is mixed with the acids it will not settle immediately. The method of making the sulphate of zinc directly in the solution is as follows:—

Take 1 gallon of yellow aquafortis (38°), and place in a stone crock, which is surrounded with cold water. The cold water is to keep the heat, which is formed by the reaction, from evaporating the acid. Now add metallic zinc in small pieces at a time until the acid will dissolve no more. The zinc may be in any convenient form—sheet clippings, lumps, granulated, or any other shape which is such that it may be added little by little. If all is added at once, the action is so violent that it will boil over. When the acid will dissolve no more zinc, it will be found that some of the acid has evaporated by the heat, and it will be necessary to add enough fresh acid to make up to the original gallon. When this is done, add 1 gal. of strong oil of vitriol. The mixture should be stirred with a wooden paddle while the oil of vitriol is being added.

As the sulphuric acid is being added, it will be noticed that the solution begins to grow milky, and finally the whole has the consistence of thick cream. This is caused by the sulphuric acid (oil of vitriol) precipitating out the sulphate of zinc. Thus the very finely-divided precipitate of sulphate of zinc is formed. If one desires to use known quantities of acid and zinc the following amounts may be taken: oil of vitriol, 1 gal.; aquafortis (38°), 1 gal.; metallic zinc, 6 oz.

In dissolving the zinc in the aquafortis it is necessary to be sure that none remains undissolved in the bottom, as this would spoil the results.

The dead or matt dip is used hot, and, therefore, is kept in a stone crock surrounded with hot water. To use it, the articles to be matted are polished and cleaned in the usual manner, and the dip thoroughly stirred with a wooden paddle so as to bring up the sulphate of zinc which has settled to the bottom. Now dip the work in the solution and allow it to remain until the requisite matt is obtained. This is a point which can be learned only by experience. When the brass article is first introduced,

there is a rapid action on the surface, but in a few seconds this slows down so that there is scarcely any. Now remove the article and rinse and immediately dip into the usual bright dip. This is necessary for the reason that the dead dip produces a dark coating upon the surface, which, were it left on, would not show the real effect or the colour of the metal. The bright dip, however, removes this and exposes the true dead surface.

The usual rule for making up the dead dip is to use equal parts of oil of vitriol and aquafortis, as just described: but these may be altered to suit the case. More oil of vitriol gives a finer matt, while a larger quantity of aquafortis will give a coarser matt. When the dip becomes old it is unnecessary to add more zinc, as it never requires it, on account of a little going into the solution each time anything is dipped. After a while, however, the solution becomes loaded with copper salts, and should then be thrown away.

A new dip does not work well, and will not give good results when used at once. It is usual to allow it to remain overnight, when it will be found to be in a better working condition in the morning. A new dip will frequently refuse to work, and the addition of a little water will often start it. The water must be used sparingly, however, and only when necessary. Water, as a usual thing, spoils a dead dip, and must be avoided. After a while it may be necessary to add a little more aquafortis, and this may be introduced as desired. Much care is needed in working the dead dip, and it is something that requires constant watching and experience, if uniform results are to be obtained. The chief difficulty in working the dead dip is to have to match a given article which is brought to the dipper. No difficulty is found in producing the dead dip, if the solution is made up properly; but to have to match what is on a sample that has been submitted is one that tests the skill of a dipper more than anything else. The only way that it can be done is to "cut and try," and add aquafortis or oil of vitriol as the case requires.

The dead or matt dip can be used only upon brass or German silver. In other words, only on alloys that contain zinc. The best results are obtained from yellow brass high in zinc. ('Brass World.')

Heating.—A lacquering stove can be very readily made. If it is to be heated by solid fuel it is simply a cast-iron plate laid over a brick-built fire-box, a flue being made to come under the plate (like the flue beneath the hot-plate of a kitchen range) or not, according to the size of the plate. It is a hot-plate in every sense of the word, but its temperature is not made quite so high as that of a cooking stove. As mentioned elsewhere the general temperature of metal goods to be lacquered is that of boiling water (212° F.), but, as a rule, the operator judges the heat by touching the goods, as the application of a thermometer is not easily done.

For gas heating, a wrought-iron plate is used, just thick (stiff) enough to properly carry the articles that are being treated. ⅛-in. plate is customarily used. This can be bent up in the form of an enclosed box, as Fig. 31, or it may be a plate with its edges turned down and provided with a short leg at each corner. The enclosed box

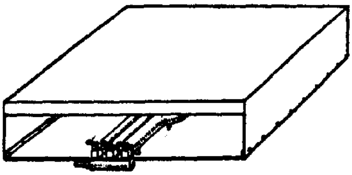

FIG. 31.

form is best, as admitting of the least escape and waste of heat from the burner or burners. In either case some sort of stand would be required to bring the plate up to working level, either a table (with some sand or silicate cotton on it if it is a wooden table), or an angle-iron frame with legs. The size of the lacquering stove or plate might be, for medium requirements, 3 ft. by 2 ft. 6 in. by 6 in. deep (high). For heating purposes a concentric triple or quadruple ring burner (a form of ring burner with three or four rings within one another, each controlled by a separate tap) might be used, this form of burner admitting of the heat being regulated to the work. If the whole of the plate should be required at full heat, it would be desirable to have two burners for a plate of the size given above. If it can be arranged that the burners be drawn out of the enclosed area for lighting, the possibility of accidents will be avoided.

In dealing with tubes it is usually found most convenient to give the required heat either by filling them with boiling water (with corked ends), or letting steam blow through them. Small articles like screws, nail heads, etc., can be inserted in a piece of cardboard and a number done at once. The lacquering must be done as quickly as possible after polishing, otherwise the surfaces will become air-tarnished and not give the best results. If the lacquering cannot be done at once, the polished goods can be protected by smearing over with oil, or be kept under clear pure water, or wrapped closely in cloths. Before lacquering the oil or water must be very carefully removed and the goods well rubbed with dry whiting.

Lacquers for Brass.—It may be briefly said at the outset that fluid lacquer consists of shellac and alcohol (methylated spirit), approximately ½ lb. of shellac to 1 gallon of spirit. The lac dissolves in the spirit, the mixture being agitated occasionally, no heat being needed. When dissolved the clear part is poured off and is ready for use, but if not sufficiently clear it is filtered through paper. In some lacquers a resin is introduced, the quantity of lac being reduced accordingly. Colouring matters are nearly always added to afford an enriched effect.

The following seven recipes are a list of what may be termed ordinary lacquers for dipped brass:—

(1) Seed-lac, dragon's blood, annatto, and gamboge, each 4 oz.; saffron, 1 oz.; wine spirit, 10 pints.

(2) Turmeric, 1 lb.; annatto, 2 oz.; shellac and gum juniper, each 12 oz.; wine spirit, 12 pints.

(3) Seed-lac, 6 oz.; dragon's blood, 40 gr.; amber and copal triturated in a mortar, 2 oz.; extract of red sanders, ½ dr.; oriental saffron, 36 gr.; coarsely powdered glass, 4 oz.; absolute alcohol, 40 oz. This is very good.

(4) Seed-lac, 3 oz.; amber and gamboge, each 2 oz.; extract of red sanders, ½ dr.; dragon's blood, 1 dr.; saffron, ½ dr.; wine spirit, 2 pints.

(5) Turmeric, 6 dr.; saffron, 15 gr.; hot alcohol, 1 pint. Strain the tincture and add—gamboge, 6 dr.; gum sandarach and gum elemi, each 2 oz.; dragon's blood and seed-lac, each 1 oz.

(6) Alcohol, 1 pint; turmeric, 1 oz.; annatto and saffron, 2 dr. each. Agitate frequently for a week, filter into a clean bottle, and add seed-lac, 3 oz. Let stand, with occasional agitation, for about 2 weeks.

(7) Gamboge, ½ oz.; aloes, 1½ oz.; shellac (fine), 8 oz.; wine spirit, 1 gal.

Of the above No. 3 is the best lacquer for fine results, such as for optical work, microscopes, etc.

If this lacquer comes off, either the metal was not clean when applied, or else it was put on cold. The metal should be heated to a point that the lacquer dries as fast as the brush passes over. Work is often spoiled in lacquering. Be sure and get the best alcohol, and see that the things are sufficiently hot before putting on the lacquer; heat after lacquering, and it will stand well. Damp will affect the best lacquering. Circular things may

be done in the lathe, going quite slow, and working a good body by going over several times.

Colouring Lacquer.—A very useful amount of information is afforded by The Atlas Chemical Co. (Sunderland) relating to lacquers, as the basis is first described, then the methods of colouring as desired. It is as follows :—

Plain Lacquer Varnish.—4 oz. sandarach, 12 oz. button shellac, 2 quarts alcohol (methylated spirits). Churn for twelve hours, then strain and settle. Decant the clear liquid in jars and cork or secure them soundly.

Black Stain for above Varnish.—Dissolve 12 oz. of spirit black in 1 gallon of methylated spirit, shaking frequently. This will take about two days. To 2 quarts of the varnish add ½ pint of this stain.

Red Stain for above Varnish.—2 oz. dragon's blood, 3 quarts of methylated spirit. Prepare as described with black stain. To 6 pints of the varnish add 5 pints of this stain.

Rose Stain for above Varnish.—The same as the last, but to 6 pints of varnish add only 2 pints of the red stain.

Yellow Gamboge Stain for above Varnish.—2 oz. gamboge, 3 quarts of methylated spirit. Prepare as described for black stain. For Pale Gold Lacquer, to 6 pints of the varnish add 1½ pints of gamboge stain and ¾ pint of red stain.

Turmeric Stain for above Varnish.—4 oz. turmeric, 1 quart of methylated spirit. Prepare as described for black stain. For a Deep Gold Lacquer, to 5 pints of the varnish add 1 pint of turmeric stain, 1 pint of red lacquer, and 2 pints of red stain.

All the stains take two or more days to make and should be left 24 hours, after the last shaking, to settle. The clear portion can be decanted into tins.

The foregoing list is very useful in showing how the basis of ordinary lacquers remain the same, while the various ingredients of the many recipes are chiefly to change the colour. Annatto is also largely used for yellow colouring, either with or without the addition of turmeric. 4 oz. of annatto to 1 quart of spirit is the customary proportion. Less or more makes the lacquer lighter or darker. Pulverised glass, when appearing in a recipe, is only added as a vehicle to assist (in the making) in carrying down impurities.

Common Clear Lacquer.—French resin 7 lb., methylated spirit 1 gallon, castor oil ½ oz.

Green Lacquer—Gamboge 1 oz., elemi 1 oz., sandarach ½ oz., turmeric 6 oz., shellac 5 oz., methylated spirit, 1½ gallon. Digest.

Lacquer for Bright Tin-ware.—Seed-lac 6 oz., methylated spirit 1 quart. Aniline colours to suit. Allow the mixture to stand about ten days, shaking it once a day or oftener. When ready strain through fine muslin.

As aniline dyes are apt to fade, more permanent but less transparent colours may be used, when required, such as prussian blue, carmine, gamboge, etc. These would be ground up in turpentine.

Gold Lacquers.—(1) Pale lac, in grains, gamboge, dragon's blood, and annatto, each 12½ oz. ; saffron, 3½ oz. Each gum is dissolved separately in 5 pints alcohol, and the annatto and saffron are separately infused in a like quantity of alcohol. The ingredients are mixed to form any particular tint desired.

(2) Turmeric (ground), 1 lb. ; alcohol, 2 gal. ; macerate for one week, strain by expression, and add gamboge, 1½ oz. ; pale shellac, ¾ lb. ; gum sandarach, 3½ lb. Strain, and add turpentine varnish, 1 qt. Other lacquers are prepared in a similar way from alcohol and shellac, a solution of the colouring ingredients, as dragon's blood, gamboge, etc., being kept on hand, and added to produce any required tint.

(3) 2 parts seed-lac, 4 sandarach, 4 elemi, 40 alcohol. Alcoholic solusions of gamboge and dragon's blood, or fuchsin, picric acid, Martin's yellow, and coralline, are separately prepared, and added to the above in quantities

ascertained by trial to impart the desired colour. To remove the marks left by the brush, and to impart lustre, the varnish, after drying, is polished. This is effected by first rubbing with powdered pumice and water, and next with an oiled rag and tripoli, until the desired polish is produced; the surface is afterwards dried with a soft linen cloth; any greasiness is removed by means of powdered starch, and the process is finished by rubbing with the hand. Great care must be taken that the surface to which varnish is applied be free from grease or smoke, which prevents all oil-varnish from drying.

(4) Turmeric, 1 dr.; gamboge, 1 dr.; oil of turpentine, 2 pints; shellac, 5 oz.; gum sandarach, 5 oz.; dragon's blood, 7 dr.; thin mastic varnish, 8 oz. Digest with occasional agitation for 14 days in a warm place, then set aside to fine, and pour off the clear.

(5) 1 lb. ground turmeric, 1½ oz. ground gamboge, 3 lb. ground gum sandarach, 1 lb. ground shellac (bleached), 2 gal. alcohol, 3 pints turpentine varnish. Put the whole into a suitable vessel, cork close, and agitate until dissolved. When ready, pour off the clear part carefully, and store in tins or glass bottles.

(6) 1 gal. methylated spirits of wine, 10 oz. seed-lac bruised, and ½ oz. red sanders; dissolve and strain.

(7) A gold lac, remarkable for its great hardness and beautiful colour, on being analysed by Dr. R. Kayser at Nuremberg, gave as its constituents picric acid and boracic acid. Thereupon a clear shellac solution was mixed with picric acid and about 1 per cent. crystallised boracic acid, each being previously dissolved in alcohol, and the resulting lac possessed all the advantages of the former one.

(8) An imitation of Chinese gold lacquer may be prepared by melting 2 parts copal and 1 shellac until thoroughly mixed, and adding 2 parts hot boiled oil. Then remove from the fire and gradually add 10 parts oil of turpentine. To colour, add gum gutta for yellow and dragon's blood for red, dissolved in turpentine.

Coloured Lacquers for Bright Metals.—These are prepared by making coloured resinates and dissolving the resinate in turpentine. The colour of the resinate depends on the nature of the salt used to precipitate the resin from the alkaline solution. The following procedure is typical of preparing such resinates:—

Dissolve sandarach or mastic resin in a strong solution of potash by boiling it until no more resin can be dissolved, then dilute the solution with water, and precipitate the resin from the solution by stirring in a solution of acetate or sulphate of copper. The precipitate will be coloured green. Collect the precipitate in a filter, and wash it with water; then dry it carefully, and afterwards dissolve it in warm oil of turpentine. By using sulphate of iron—ferrous sulphate—a brown resinate is produced, whilst alum or sulphate of calcium will precipitate the resin as a white body.

Lacquer for Steel.—This can be prepared like a plain lacquer varnish, but with the addition of a little copal and resin. 1 quart methylated spirit, ½ lb. button-lac, 1½ oz. copal, 1 oz. medium resin. Digest.

Lacquer for Bright Steel.—Spirits of wine 1 quart, mastic resin 8 oz., camphor 4 oz., sandarach resin 12 oz., gum elemi, 4 oz. Digest, filter, and use the lacquer cold. More or less alcohol can be used, according to the consistence desired of the lacquer. Use this lacquer cold. No stoving required.

Lacquer for Tinfoil.—Methylated spirit 3 quarts, shellac 21 oz. Dissolve and filter, and add to the solution gum elemi 6½ oz., Venice turpentine 8 oz. Allow these mixtures to digest for some days in a warm place, then filter. This varnish may be coloured, if desired with the usual colouring materials.

Lacquer for Zinc.—(*a*) Methylated spirit 1 quart, gamboge 5 oz., annatto 5 oz., shellac 15 oz., seed-lac 15 oz., dissolved in 5 pints of alcohol. Digest,

and then add Venice turpentine 1½ oz., dragon's blood 1½ oz., and allow to digest for a week before pouring off the clear fluid for use.

(b) Shellac 8 oz., seed-lac 9 oz., gamboge 2 oz., annatto 2 oz., dragon's blood ½ oz., Venice turpentine ½ oz., methylated spirit 4½ pints. The gamboge and annatto should be digested in about a pint of the spirit, while the shellac is put in the remainder. When dissolved, mix and add the turpentine and dragon's blood. If kept in a warm place it will be ready for use in a few days.

Zapon Cold Lacquers are well known in the metal trades, but their preparation is not generally known. The following formulæ, however, are the lines on which these celluloid varnishes are produced: Mix together acetate of amyl 3 oz., acetone 3 oz., methylated sulphuric ether 3 oz., camphor 4 oz., and dissolve in the fluid 1 oz. of celluloid. ('The Engineer.')

Lacquer for Copper Goods.—Shellac 5 oz., sandarach 5 oz., camphor 2 oz., mastic 3 oz., methylated spirit 14 oz.

Lacquers for Wood (See also *Japanning*).—A lacquer of great elasticity, perfectly supple and not liable to peel off, is made in the following manner: About 12 lb. oil varnish is heated in one vessel, and 3½ lb. quicklime is put into 2½ lb. water in another. As soon as the lime causes an effervescence, 5½ lb. melted rubber are added. This mixture is stirred, and then poured into the vessel of hot varnish. The whole is stirred so as to be thoroughly mixed, then strained and allowed to cool, when it has the appearance of lead. When required for use, it is thinned with the necessary quantity of varnish, and applied with a brush, hot or cold—preferably the former. This lacquer is useful for wood or iron, and for walls; it will also render waterproof cloth, paper, etc.

Tonbridge Ware.—This is prepared in the following manner. The grain of the wood is filled with plaster of Paris and glue size. As a matter of course the wood should be white, such as pine, chestnut, lime, or holly. After filling up the grain, well paper the surface smooth with glass paper; no oil must be used on any account. If the appearance is not satisfactory when papered down, give another coat of glue size, and plaster of Paris, paper down smooth, then give the article a coat of varnish made as follows: ½ lb. flake white, ½ gill spirits of turpentine, ½ gill spirit varnish, such as white hard varnish or glaze. (N.B.—It must be borne in mind, as the quality of flake white and the thickness of the varnish vary, the quantity must not be taken as quite exact, but the worker must be guided by circumstances.) When the first coat is dry, paper down and give another coat; paper down again and give a final coat. When quite set give the whole piece of work a coat of white hard varnish, or, if preferable, a coat of glaze. Work done in this style will last for years. Should it at any time get bruised, it may be papered down and revarnished. In grinding colours for coloured work, great care should be taken that the mixture is worked quite smooth, using spirits of turpentine only. Never mix with varnish until the colour has been well mixed with turps, and never mix a greater quantity than will be used at any one time. For colour japanning the following colours are used: Flake white, red lead, vermilion, prussian blue, chrome yellow, the various ochres, vandyke brown, umber, lampblack, blue black, drop black. With these any colour may be matched. For black japan a simple plan is to stain the article, or even paint it with lampblack and turps after the grain is filled up, then varnish it with black japan thinned with turps, after which give the article a coat of white hard varnish, darkened with ivory black, or it may be finished off with a mixture of gold size and ivory black, but must have two coats.

Japanese Lacquer (*Urushi*).—Urushi is the milky secretion of *Rhus vernicifera*, and is the material for the well-known Japanese lacquer var-

nish. The tree is cultivated in many parts of the country, throughout almost all latitudes, e.g. at Dewa, Aizu, Hiroshima, and in many places about Tokio; the best urushi, however, is obtained at Yoshino. The tree is very similar in aspect to the ordinary wax-tree, and attains the height of 9–12 ft. Trees about 15 years old yield the largest amount of the juice. Two sorts of the juice are generally obtained from a tree, and by different processes. They are distinguished as ordinary "ki-urushi" and "seshime-urushi."

Ki-urushi (or raw lacquer) is the better of the two, and is collected best in June by making shallow cuttings in the stem of the tree, when it exudes as drops from between the outer and inner barks. A single tree yields on an average about 2¼ grm. of this kind of juice. Branches and twigs of the tree, some of which are usually cut down each year, when steeped in water for some months and afterwards warmed in the fire, give out an inferior kind of juice; this is seshime-urushi, which is used as under varnish after being mixed with some drying oil.

The juice is never sent to market in the form in which it comes from the tree, but is usually mixed with more or less of what is called "mokuyiki" (literally wood-juice), e.g. what is ordinarily called Yoshino. Urushi consists of 60 per cent. of the genuine juice with 40 per cent. of mokuyiki, while the inferior quality contains as much as 70 per cent. of the latter substance. Further, in the hands of varnish makers, some quantity of linseed-oil is generally added to the already mixed juice, which, if excess is avoided, does not much impair the drying power of urushi.

Different colours are imparted to urushi by the addition of body pigments, such as lampblack, vermilion, indigo, orpiment, etc.; thus red lacquer is prepared with 20 parts of linseed-oil, 70 parts of urushi juice, and about 10 parts of vermilion, etc. Such is a rough yet general account of the extraction and preparation of urushi juice for varnish-making. The pure and unaltered urushi is a thick greyish fluid of dextrinous consistence, which under the microscope is found to consist of minute globules, some of darker, and others of lighter colour, mixed with small particles of opaque brownish matter, the whole being held mixed in the form of intimate emulsion. It has a characteristic sweetish odour, and specific gravity 1·0020 (20° C.); some specimens, such as that obtained from Hachioji, contained a good deal of bark dust and other impurities, which raise its specific gravity as high as 1·038. If the juice be exposed to moist air in a thin layer at about 20° C., it rapidly darkens in colour and dries up to a lustrous translucent varnish. It contains a small quantity of volatile poison, which acts terribly on some persons, producing a very disagreeable itching.

A peculiar acid, which I now call urushic acid, is the main constituent of the original juice, as well as of the portion soluble in alcohol. The juice also contains a very small quantity of a volatile poisonous body, which also passes into alcoholic solution, being almost completely driven out during the drying of the acid at 105°–110° C. It is a pasty substance of somewhat dark colour, having the characteristic smell of the original juice, readily soluble in benzene, ether, carbon bisulphide, less easily in fusel oil and petroleum of high-boiling point, completely insoluble in water. Its specific gravity taken at 23° C. is 0·9851; it remains unchanged at 160° C., and above 200° C. decomposes slowly with carbonisation. Exposed to the air, it neither dries up, nor shows any sign of change as the original juice does, and in other respects it is a very stable body. From the alcoholic solution of the acid many metallic salts can be produced, most of which are slightly soluble in alcohol, but almost insoluble in water.

Gum is another normal constituent of urushi, and forms 3–8 per cent. of the original juice.

As gum is insoluble in alcohol, it is conveniently separated by treating that portion of the original juice insoluble in alcohol with boiling water, filtering, and finally evaporating the aqueous solution of gum over the water-bath till the weight of the substance remains constant. In this way a friable light-coloured substance is obtained, tasteless and inodorous; this is the anhydrous gum.

A mixture of gum and urushic acid (and with water) in the proportion in which they exist in the juice, does not undergo any change whatever, even when exposed to the condition most favourable for the drying of the lacquer. Moreover, part of the gum can be extracted in an unchanged state from the once perfectly dried lacquer; and since it exists in the original juice in the form of aqueous solution, it probably serves to keep the constituents of the juice in a state of uniform distribution and intimate emulsion. It may also act as a binding material, and assist the adhering power of the lacquer when laid upon any surface.

The results, so far arrived at, may be summed up in the following statement:—

Urushi juice (lacquer) consists essentially of four substances, viz. urushic acid, gum, water, and a peculiar diastatic matter; and the phenomenon of its drying is due to the oxidation of urushic acid, $C_{14}H_{18}O_2$, into oxyurushic acid, $C_{14}H_{18}O_3$, which takes place by the aid of diastase in the presence of oxygen and moisture. (H. Yoshida.)

It has been said that the process of lacquering, as known to the old Japanese workers, is, if not quite lost, becoming rapidly so in the present day, and that the modern system of lacquering is not calculated to stand the ravages of time, as was the work of a generation or two since. It is not to be supposed that the cheap lacquered articles of the present day, that are made simply to sell, will ever bear comparison in workmanship with the more costly and durable work, the make of which, as well as the polish, are, notwithstanding their great age, as perfect as when they left the hands of the workman.

The date of the discovery of the art of lacquering, in Japan, is given by the Japanese as A.D. 724; some authorities, however, consider it to have been later, probably indeed about 889 or 900. It seems, however, not to have attained to any degree of perfection till the year 1290, for the name of a distinguished painter in lacquer, who lived at that time, is still handed down as the founder of a particular school of art in lacquer-painting. From that time, it developed until it attained its present perfection.

A very elaborate report on the lacquer industry of Japan has recently been produced by J. J. Quin, H.M. Acting Consul at Hakodadi. This report has been drawn up chiefly as a description of the articles of various kinds illustrative of the lacquer industry of Japan, collected for the use of the Museum of Economic Botany at Kew. This collection is a most complete one, and is now exhibited in the No. 1 Museum, Royal Gardens, Kew. It comprises not only a fine series of finished lacquer articles, such as boxes, cabinets, bowls, trays, etc., both of ancient and modern workmanship, but also a very complete set of the instruments and appliances used in the manipulation of the lacquer-ware, including specimens of the trunk of *Rhus vernicifera*, gashed to show the mode of extracting the juice or lacquer, together with the iron instruments used for this purpose; also a complete set of the lacquers themselves, and of the colouring matters used.

The following notes are abstracted from the report referred to:—

The best transparent lacquer comes from the districts of Tsugaru, Nambu, Akito, and Aidzu. It is largely used by the workers of Kioto, Osaka, and the southern provinces, but though also used in Tokio, is not so much appreciated there as the lacquer produced from the neighbourhood of Chichibu, in the province of Mus-ashi,

from Nikko, in Shimotsuke, and that produced in the provinces of Kodzuke and Sagami, which hardens more rapidly, and is the best for black lacquer. There are some districts the lacquer obtained from which is best for certain kinds of work, but is not so well adapted for others. The kind which is used for transparent lacquer is mixed in large tubs, to ensure a uniform quality, and being allowed to stand for some time (say a week or 10 days), the best portion, which is ordinarily 70 per cent. of the whole, is skimmed off. This is used for Nashiji and Shu lacquer, while the remainder is used for making inferior mixtures, such as Johana, etc. Almost all the various classes of lacquer are similarly dealt with to ensure uniformity, as some qualities dry much quicker, and are better than others, and the slow-drying qualities would otherwise remain unsold.

The woods chosen for lacquering on are naturally selected according to the use to which the lacquered article is to be put. For shelves, cabinets, boxes of all kinds, the following are principally used, and are set down in the order of their excellence: *Hinoki* (*Chamaecyparis obtusa*): by far the best wood for making boxes, as it does not warp. *Kiri* (*Paulownia imperialis*): light wood used for clothes-boxes, which are only lacquered on the outside. It is also used for making tea-caddies, as the wood has no smell. *Hōno-ki* (*Magnolia hypoleuca*): sword sheaths have hitherto been made of this wood. *Sawara* (*Chamaecyparis pisifera*): a wood of a coarser grain than *Hinoki* (*C. obtusa*). *Hime-komatsu*: used for carved figures of men, animals, etc. It is not liable to split and crack. *Tsuga* (*Abies tsuga*), *Hiba* (*Thujopsis dolabrata*): for making cheap articles. *Akamatsu* (*Pinus densiflora*), *Sugi* (*Cryptomeria japonica*): only used in making the cheapest and most inferior goods. The following woods are mostly used in the manufacture of such articles as are turned in a lathe, as bowls, rice-cups, round trays, etc.: *Keyaki* (*Planera japonica*), the best being obtained from the province of Hiuga. *Shoji*, the scientific name of which is unknown. *Sakura* (*Prunus pseudocerasus*). *Katsura* (*Cercidophyllum japonicum*). *Teho* (*Gingko biloba*). *I-go*: grown in large quantities in the neighbourhood of Hakone. It is principally used in the manufacture of cheap articles. *Buna*: principally used in the district of Aidzu for the same kind of utensils as *keyaki* and *sakura*, but being a brittle wood, it cannot be turned in a lathe to make such fine articles; those made of this wood are coarse and heavier. For raised gold lacquering over unvarnished surface, the following ornamental woods are often used: *Shitan*, *Tagaysan*, *Karin* (quince), *Kuwa* (mulberry), *Keyaki* (*Planera japonica*), ornamental grain.

VARIOUS KINDS OF LACQUER AND MIXTURES USED.—(A) FOR PLAIN WORK.—*Ki-urushi* (crude lacquer) is the generic name by which all lacquer obtained from the trunks of live trees is known. It forms the basis of nearly all the various mixtures used in making lacquer ware.

Seshime (branch lacquer).—This kind is obtained from the branches of the trees as already described; but the yield is only 1 per cent. in comparison with other lacquer. As, however, in working, the proportion of nearly 90 per cent. is required, the lacquer manufacturers sell a mixture which is stated to be a compound of true branch lacquer, the best crude lacquer, *ura-me* and *tomé* lacquer, *funori* (seaweed jelly), sweet potatoes grated fine; coloured as may be necessary with soot. The proportions in which these materials are used cannot be ascertained, and indeed each manufacturer uses his own special mixture, but the extraneous additions are believed not to injure the quality of the whole. True branch lacquer becomes extremely hard when once dry, but used alone will not dry under 20 days; so that now, when time is an object, the pure sap is but little used.

The price of pure branch lacquer is, owing to the difficulty in drying, only 70 per cent. of ordinary good lacquer.

Rō-urushi (black lacquer).—This is made by adding to crude or branch lacquer, about 5 per cent. of the tooth dye (*haguro*) used by women, a liquor formed by boiling iron filings in rice vinegar, and exposing it to the sun for several days, stirring the mixture frequently till it becomes a deep black.

In preparing all lacquer—from the crude lacquer to the various mixtures—the principal object is to get rid of the water that exudes from the tree with the sap. To effect this, it is exposed in broad flat wooden dishes, and stirred in the sun. This, however, alone will not cause the original water to evaporate, so from time to time—ordinarily about 3 times in the day—a small portion of clean water is stirred in, say 1 per cent. each time, for 2 or 3 days, according to the heat of the sun. All the water then evaporates together. No lacquer will dry until this process has been gone through. If the lacquer is old—i.e., has been tapped a long time before using—it is much more difficult to dry. In such a case, a portion of fresh lacquer is added to the old by wholesale dealers, or else the manufacturers, instead of water, sometimes mix *saké* (rice beer) or alcohol to "quicken" it.

A very remarkable property of lacquer should be mentioned. If crude lacquer, which is originally of the colour and consistence of cream, is exposed to the sun for a few days without adding water, it loses its creamy colour, and becomes quite black, or nearly so, but also becomes thinner and transparent, or rather translucent, as can be seen when it is smeared on a white board. It will not now, however, dry if applied to an article, even if kept a month or more in the damp press. But if water is mixed with the lacquer which has thus been exposed and become black, it at once loses its black colour and transparency, and becomes again of a creamy colour, though slightly darker, as if some coffee had been added, than at first. After evaporating this water, it can then be used like any ordinary lacquer, either alone or in mixtures, and will dry in the damp press, during which process it again turns black. What lacquer-workers have found their greatest stumbling-block is the difficulty of obtaining a clear transparent varnish. What is called transparent varnish is really black to the eye, and requires grinding and polishing after application before it presents a brilliant surface, becoming also much lighter after a little time.

It would be a new era in the manufacture of lacquer-ware if a method could be discovered of rendering the lacquer varnish perfectly clear and light-coloured, when so desired, without depriving it of its drying qualities, and also if colours could be used with it other than those hereafter mentioned.

Nakanuri-urushi (middle-painting varnish).—This is merely the crude lacquer. After having been exposed for some time to the sun to darken it, and to get rid of all water, it is used for under-coats for making first-class ware.

Nuritate-urushi (finishing lacquer). This is a mixture of crude lacquer and a little turpentine with *tō-midzu* (whetstone water), being the mixture obtained from whetstones on which blades have been sharpened. In it is some 7 to 8 per cent. of iron, and after mixing, the whole is exposed to the sun, both for the purpose of getting rid of all the water and to darken the colour. This is used for final coats of cheap lacquer, which is not polished afterwards.

Jō-hana-urushi.—This is a mixture of the above kind, with oil obtained from the *ye* plant (*Perilla ocymoides*). This is used for still more common kinds requiring no after polishing, and the lacquer does not present a hard surface.

Jō-chiu, called in Kioto, *Chiu-hana*; *Jō-tame*, called in Kioto, *Ge-hana*.—These contain more and more oil, and are used for the commonest articles,

such as for varnishing clogs, clothes-baskets, etc. These three last kinds give a high polish, but the lacquer does not last.

Shu-urushi (vermilion lacquer).—This is the best crude or transparent varnish mixed with *ye* oil (*Perilla ocymoides*), sometimes as much as 50 per cent. being added. It is then exposed to the sun, and water is added, which is afterwards evaporated. This kind is only used for red (whence its name) and coloured lacquers; the colours being added at the time of application. It requires no after-polishing.

(B) FOR LACQUERING WITH GOLD.—*Nashiji-urushi* (pear basis lacquer), or *Suki-urushi* (transparent lacquer).—The first name is that best known in the trade, as indicating that it is required for using over gold, silver, or tin powdering. It consists of the finest crude lacquer obtained from old trees. As stated previously, the lacquer is allowed to stand till all dirt and foreign matter have sunk to the bottom, when the best is skimmed off, and after being exposed to the sun to evaporate the water in the usual manner, and carefully filtered, it is ready for use. Except when used for the highest class of gold powdering, a certain proportion of gamboge is mixed with the lacquer to give the powder a fine yellow colour.

N.B.—The following ten kinds are all bought by the lacquer-workers ready prepared from the manufacturers. Any further mixtures used by them are made as required, colours added, etc.

Seshime-urushi (branch lacquer) and *Rō-urushi* are used also in making gold lacquer.

Yoshino-urushi.—This is crude lacquer from the district of Yoshino, in the province of Yamoto. It dries quickly, and closely resembles transparent varnish. It is used when giving the final coats before polishing.

Yoshino-nobe-urushi (Yoshino spreading lacquer).—Same as above, with the addition of about ½ of camphor to render the lacquer thinner and more easy to spread.

Seshime-nobe-urushi (spreading branch lacquer). — This is merely branch lacquer with the same proportion of camphor as above; when cheap work is required, more camphor is used till the proportions are reversed. This renders the mixture very soft, and a small quantity can be spread over a large surface.

Shita-maki-urushi (under-coat lacquer).—A mixture of branch lacquer and *benigara* (red oxide of iron), in equal parts by weight.

Ke-uchi-urushi (inside line lacquer). This is the same as above, but it is allowed to stand for about 6 months after mixing before it is used. By this time it has got thicker, and the very finest lines can be drawn without fear of their running; they, moreover, stand out better.

Shita-maki-nobe-urushi (under-coat spreading lacquer).—Same composition as above, with the addition of a little camphor to make the lacquer thin. It thus goes much further, and causes a great saving when lacquering with powdered gold-leaf (*keshi fun*), for which it is best suited. As in the other mixtures, the more camphor is used the thinner it renders the lacquer, and the less gold is required.

Taka-maki-urushi (raised lacquer).—To make this, a certain quantity of *ro* or *nuritate* is taken and divided into 3 parts. To 1 part is added lampblack and camphor, in equal proportions of bulk. These, after being well mixed, are boiled together; then the other 2 portions are added, and the whole stirred together, and afterwards filtered through paper. It is boiled more or less according to the season. In summer, when lacquer dries quickly, it is boiled for a longer period; while in winter or during cold weather, when lacquer naturally takes longer to dry, the mixture is boiled for a shorter time. The reason why *Taka-maki* is thus purposely rendered soft, is explained by the fact that otherwise the upper surface would harden at once,

while the under portion, *Taki-maka* (being applied thickly), being excluded from the upper air, would not be able to dry, and later, the top surface would crack and show fissures; whereas the introduction of camphor renders it soft and much slower to dry, and the whole has thus time to harden equally. Camphor being volatile, is gradually lost, and the composition becomes quite hard.

Ro-se-urushi (a mixture of black and branch lacquer).—This is used for the lacquer coating upon which gold, silver, or tin powder is scattered, except in such cases where the grain of the wood is to be shown, when *Nashiji* lacquer is used instead.

Kuma-urushi (shading lacquer).—A mixture of *Jōhana* lacquer and lampblack, used for final shading in the feathers of birds or animals, or for drawing hair, etc., on flat and raised gold lacquer.

It should be noticed that whenever lampblack is mentioned as a mixture, it is used for the superior kinds, wood- or coal-soot being used for inferior articles.

IMPLEMENTS AND MATERIALS USED IN THE MANUFACTURE OF PLAIN LACQUERED WARE. — *Hera.* — A spatula made of *Hinoki* (*Chamæcyparis obtusa*), used for applying the under or priming coats and for mixing the lacquer.

Haké.—A flat brush made from human hair, used for laying on the lacquer.

Kokuso. — Finely-chopped hemp. Mixed with lacquer, it is used for covering joints.

Nuno. — Hempen cloth, used for pasting over the wood to prevent it splitting, and to strengthen corners, etc. For very fine work and small articles, silk is used.

Ji-no-ko (burnt clay).—Afterwards reduced to a very fine powder. *Pounded bricks are often used.

To-no-ko.—A fine kind of clay, which is procured from Mount Mari, near Kioto. This is likewise burnt, and reduced to a fine powder.

Sumi.—Charcoal made of *Hōnoki* (*Magnolia hypoleuca*), used for smoothing down the under-coats; it has rather a rough grain. Also charcoal made from *Hiyakujikkō* (*Lagerstrœmia indica*). This is very soft and of a fine grain, and is used for the final smoothing before hand polishing. This kind is called by the trade *Kō-iro-sumi* (black-coloured charcoal).

To-ishi.—Whetstones of 4 different qualities of fineness: *Ara-to* (rough), *shiro-to* (white), *awo-to* (green), and *nagura*, the last being the finest. These are used for smoothing down the priming coats.

Tsuno-ko (horn powder).—This is made of calcined deer's horns reduced to a fine powder, and is used for the final polishing with the finger.

To-kusa (*Equisetum*). — A kind of scouring rush, used for smoothing the lacquer.

Kaki-no-shibu (persimmon juice).—This is used when no ground lacquer is required, as in the Aidzu lacquer, or when the grain of the wood is shown.

Nikawa (glue).—This is used to mix with the groundwork for cheap kinds of ware, instead of lacquer.

Yuyen-sumi (lampblack).—Used for groundwork of cheap articles, mixed with persimmon juice. For still more common ware, soot of any kind is used.

Gofun (whiting).—Made from burning old shells, such as are obtained from the ancient kitchen middens; used for mixing with glue to make the groundwork of common lacquer.

Shō-no (camphor).—Used for mixing with lacquer, to make it thinner and spread more easily.

Hōchō (knife).—Used for scraping off all inequalities of the hempen cloth after it is pasted on the article, etc.

Yoshino-gami.—A very thin kind of paper, made at Yoshino; used for filtering the lacquer before using it.

Jō-ban.—A box with a very hard lacquered lid, usually containing drawers for the various pencils, etc. The lid is used for mixing the lacquer on while working.

Tsuno-ko-ban. — Board for mixing and powdering the deer's-horn ashes

before using; generally made of cherry-wood or oak.

Muro.—A cave or cellar underground is used, where practicable; otherwise, an air-tight case, made of wood, with rough unplaned planks inside. These are thoroughly wetted before the lacquered article is put in to dry, which occupies a period varying from 6 to 50 hours, according to the time of the year or style of the lacquer. Lacquer will not dry or harden properly in the open air; it absolutely requires a damp closed atmosphere to do so, otherwise it would run and always remain sticky.

The following are mixtures made by the workmen as required:—

Kokuso. — A mixture of finely chopped hemp, with rice starch and branch lacquer sufficient to make a thick paste.

Jino-ko (No. 1).—Powdered burnt clay and branch lacquer, mixed together in the proportion of 1 part of clay to 2 parts of lacquer.

Jino-ko (No. 2).—The same, mixed in the proportion of 10 parts of clay to 13 of lacquer, and a little water.

Jino-ko (No. 3).—The same, mixed in the proportion of 10 parts of clay to 8 parts of lacquer and 2 parts of thin rice starch. This mixture is known in the trade as *Han-dan-ji* (half-step basis).

Jino-ko (No. 4).—The burnt-clay powder mixed with liquid glue only in such proportions as will resemble the consistence of lacquer.

Kiri-ko.—A mixture of *Jino-ko* and *Tōno-ko* in equal portions with 1½ of branch lacquer. This becomes very hard.

Sabi.—A mixture of 2 parts of the burnt clay from Mount Mari to 1½ of branch lacquer, with just sufficient water to mix the clay into a paste.

An inferior class of *Sabi* is made by putting in less lacquer—as little as 8 parts of lacquer being used to 20 of the clay. Less lacquer cannot be used, as it would not stand polishing after having been dried.

Mugi-urushi.—Wheat lacquer; being a portion of wheaten flour mixed with branch lacquer to such consistence as may be required. It is used to paste the hempen cloth on to the wood.

Shin.—A mixture of rice flour with branch lacquer, used for the same purpose as wheat lacquer. Wheaten flour is the best, but being more difficult to blend with lacquer it is not so much used.

Ka-no-ji.—A mixture of whiting and liquid glue, used for under-coats or cheap articles.

Shibu-ji.—A mixture of lampblack and persimmon juice, used for under-coats in inferior ware.

The following are Modes of Applying the Lacquer:—

Honji (real basis).—The article to be lacquered is first carefully smoothed, and the wood is slightly hollowed away along each joint, so as to form a circular depression. The surface of the whole article is then given a coating of branch lacquer (this is called *Ki-ji-gatame*—hardening the wooden basis), and the article is set to dry in the damp press, or *muro*, for about 12 hours. The hollowed portions are filled with prepared *Kokuso*, which is well rubbed in with a spatula made of the wood of the *Chamæcyparis obtusa*, and the article is enclosed in the drying-press for a period of at least 40 hours. Over the *Kokuso* a coating of *Sabi* is applied, and set to dry for 12 hours. The next process is to smooth off with a white whetstone any roughness or inequalities of the *Kokuso* and *Sabi*. The article is then given a coating of wheaten lacquer, over which is stretched hempen cloth, great care being taken to spread it smoothly and leave no wrinkles or perceptible joinings, and it is then again enclosed in the drying-press for about 24 hours. After taking the article out of the press, all inequalities in the cloth—which has now under the influence of the lacquer become harder than wood—are smoothed down with a knife or with a plane. Next, a coating of *Sabi* is applied with the spatula, to hide the texture of the hempen cloth, and the article is again put in

the press for 24 hours. Next, a coating is given of No. 1 *Jino-ko*, applied with the spatula, after which the article is enclosed in the drying-press for 24 hours, and this process repeated. Next, the article is given a coating of *Kiriko*, likewise applied with the spatula, and the drying process is repeated for 24 hours; there is then a repetition of the same process, after which the article is set to dry for at least 3 days. The surface is next ground smooth with a fine white whetstone, and a hardening coat of branch lacquer is given with a spatula, and set to dry for 24 hours. A fresh coat of *Sabi* is applied with the spatula, and the article is put to dry in the press for 24 hours. When thoroughly hardened, the surface is ground with a white whetsone, as before. Next, a thin coating of branch lacquer is applied with the spatula, and the article is set to dry in the press for 12 hours. A coating of *Naka-nuri* is applied with a flat brush (*Haké*), and the article is set to dry again for 24 hours. On being taken out, the surface is ground smooth with charcoal made from *Hōnoki* (*Magnolia hypoleuca*). A thin coating of branch lacquer is given with cotton wool—old wool being chosen because less likely to leave hairs behind it—and rubbed off again with soft paper, after which the article is set to dry for 12 hours. A coating of *Rō* (black lacquer) is then applied, and the article is set to dry for 24 hours. The surface is rubbed smooth with a piece of charcoal made from *Hiyakujikko* (*Lagerstræmia indica*). The surface is partly polished with finely powdered *Lagerstræmia* charcoal, applied with a cotton cloth. A coating of *Rō* is applied very thinly with cotton wool, and this is rubbed off again with soft paper, after which the article is enclosed in the drying-press for 24 hours. The surface is now polished with an equal mixture of powdered burnt clay from Mount Mari (*To-no-ko*) and calcined deer's-horn ashes, applied with a cotton cloth and a little oil (made from *Sesamum orientale*) till a fine polish is obtained. A coating of branch lacquer is next given, applied with cotton wool very thinly, and the article is enclosed in the drying-press for 12 hours. The workman dips his finger in oil and rubs a small quantity of it over the surface, which he then polishes with deer's-horn ashes, applied with a cotton cloth, till a bright surface is obtained. A coating of branch lacquer is applied thinly with cotton wool, wiped off with soft paper, and set to dry for 12 hours. Oil is again applied, and then a final polishing with deer's-horn ashes given with the finger to the surface, which now assumes the most brilliant polish of which it is capable.

For articles that are liable to get rubbed, such as scabbards, these last 2 processes are repeated 7 or 8 times, the surface getting harder at each repetition; but this is not necessary for other articles, even of the best quality. In describing the above processes, the *minimum* time for drying has in each case been given, but for the first 25 processes the longer the article is kept in the press the better. From the twenty-eighth process to the finish it is better not to greatly exceed the times mentioned.

Kata-ji (hard basis); *Handan-ji* (half-step basis); and *Manzo* (after a lacquer-worker of that name)—modifications of the first process.

Ka-no-ji (inferior basis).—In this class the joints of the artic'e to be lacquered are frequently not hollowed away, a strip of paper being merely pasted over them, and even this precaution being often omitted. A coating of *Ka-no-ji* (whiting and glue) is applied with a spatula twice or thrice, and dried in the sun. The article is then wiped over with a wet brush and rubbed smooth with a white whetstone, and afterwards given an extra smoothing with the spatula. Sometimes a thin coating of *Nakanuri* or of branch lacquer is given to the article, but more frequently a coating of glue and lampblack, or of glue and soot mixed together, is applied. A final coating of either *Jō-hana* or *Jō-chiu*

finishes the process without any subsequent polishing.

Shibu-ji (persimmon-juice basis).—The joints of the article are prepared in the same manner, but instead of *Ka-no-ji*, 4 or 5 coats of *Shibu-ji* (persimmon juice and lampblack) are applied with a brush; these dry very rapidly, and the last coating is smoothed with *To-kusa* (*Equisetum*). A final coating of either *Jō-hana* or *Jō-chiu* is given. This kind of article is chiefly made in Aidzu, and indeed goes by the name of "Aidzu ware." It has not such a good appearance as *Ka-no-ji*, for the grain of the wood is easily traceable under the lacquer, but being made without glue, it stands water much better, and is in general request for rice-bowls and *zen* (small dinner-trays with legs, one of which is set before each guest).

Sabi-Sabi (double Sabi).—In this class of goods the joints are generally hollowed out, and a basis-hardening coat of branch lacquer is given. Paper is also pasted over the work after filling in the joints with *Koku-so*. Three coats of inferior *Sabi* are then applied, and after drying for about 12 hours in the press, the article is ground smooth with a white whetstone. Next comes a coating of branch lacquer, applied with cotton wool, and then one of *Naka-nuri*, which is ground smooth with *Magnolia* charcoal. Another coating of branch lacquer is followed by one of *Jō-hana* or *Jō-chiu*, and the article is finished without further polishing. Drying in the damp press is requisite after each process for this class of lacquer. It is manufactured only in Tokio, though the processes for the under coats of *Wakasa* lacquer are identical. Rice-bowls, drinking-cups, and luncheon-boxes, etc., are the usual articles manufactured. In this, as in Aidzu ware, the grain of the wood is traceable, and its common appearance constitutes the reason for classing it so low, but in actual excellence and durability it ought to rank fourth next to *Handan-ji*.

Kaki-awase (mixture), or *Kuro-shunkei* (black Shunkei), from the name of its inventor. In this class of goods the wood is given a basis-hardening coat of branch lacquer mixed with lampblack, over which is laid a final single application of *Jō-hana* or *Jō-chiu*. This ware is made at Tokio, and is used for cheap rice-bowls and boxes. For the commonest kind of work a mixture of glue and lampblack, or persimmon juice and lampblack, is used, instead of branch lacquer, as a ground coat.

Aka-shunkei (red Shunkei).—This kind also derives its name from the inventor. For making articles of this class, which show the natural grain of the wood, a mixture of *Yoshino* lacquer and gamboge is rubbed on with a hard brush, after which they are enclosed for a day in the press to dry, and then a coating of *Shu-urushi* (transparent lacquer, containing a proportion of *Perilla ocymoides* oil) is applied. When dry, it presents a polished surface, and it appears dark when at first finished, but in a few months becomes much lighter. A cheaper quality of *Shunkei* is made by using glue and gamboge or persimmon juice and oxide of iron for the under-coat; but though the colour has a better appearance at first, it gradually deteriorates. The best is made in the province of Dewa, at Akita. For the most part soft woods are used in making this ware.

Ki-ji-ro (colour of the grain of wood).—Well-seasoned wood is selected, and the article having been carefully smoothed, a thin coating of *Yoshino* lacquer is applied with a brush, after which it is set to dry in the press for 12 hours. A coating of best *Sabi* is then applied with the spatula, and set to dry in the press as usual. This is ground completely away with a green whetstone. A coating of *Nashiji* (pure transparent lacquer), is now given, and the article is enclosed in the press for 24 hours. It is again ground with a green whetstone till no remains of the lacquer coating are apparent. Then

follows a second coat of transparent lacquer, which, after drying as before, is ground smooth with a piece of *Hiyaku-jikko* (*Lagerstrœmia indica*) charcoal. Transparent lacquer is again applied with a piece of cotton-wool, and wiped off with soft paper, and the article is set to dry for 12 hours. Afterwards it is given a primary polish with an equal mixture of *To-no-ko* and deer's-horn ashes applied with a cotton cloth and a little oil. Next, a coating of *Yoshino* lacquer is applied with cotton-wool, wiped off with paper, and set to dry, as before. At this stage only deer's-horn ashes, with a trifle of oil, are used for polishing. This process is repeated 3 times, and results in an exceedingly brilliant polish. Only hard woods are used for this kind of ware.

Red and Coloured Lacquers.—For making best red and other coloured lacquers the first 22 processes are the same as in *Honji.* Next a mixture of *Nashiji* (pure transparent lacquer) and vermilion, or the colour desired, is given to the article, which is thereupon set to dry. The remainder of the processes are identical, except that *Yoshino* lacquer is substituted for "branch lacquer," and transparent varnish is used instead of *Rō* (black lacquer). For extra high-class work, instead of the thin coating of lacquer, which is wiped off again, a thick coating of transparent varnish is given, applied with a brush, and set to dry for about 36 hours, the further processes remaining unchanged. For second-rate articles, the colour is mixed with *Shu-urushi* (transparent lacquer containing oil), and no after-polishing takes place. The article presents a brilliant surface, and the colour is better and brighter than in the best kind, but the surface is much less hard. Many processes are omitted for cheaper articles, as is the case in black lacquer, and less lacquer and more oil is used.

COLOURING MATTERS. — *Shu* (vermilion).—For red lacquer; used also mixed with gold-dust for shading.

Sei-shitsu (green lacquer).—A mixture of *Kiō* (chrome yellow) and *Bero-ai* (prussian blue).

Muras-aki-ko (purple powder).—A mixture of white-lead and *Tō-beni* (magenta roseine).

Benigara (red oxide of iron).—Sometimes used instead of vermilion.

In the district of Aidzu the light colours are produced to the greatest perfection, viz., yellow, green, and intermediate shades. In Tokio, though the same materials are used, the result-ing colours are inferior and darker. In Aidzu no after-polishing takes place with coloured lacquers. The lacquer is applied like paint. Tokio is, however, best for black lacquer, as well as for such high-class red, etc., as are polished afterwards. These differences are attributed to some climatic influence.

The *Kioto*, so-called "black lacquer," shows a reddish-brown tinge. With the exception of Tokio, Kioto, Osaka, Kaga, Tsugaru, Wakasa, Nagoya, Suruga, and Shidzuoka, and one or two isolated places, the method of smoothing with charcoal, and afterwards polishing, is not pursued. In Tsugaru and Wakasa neither flat nor raised gold lacquer is manufactured.

It should be mentioned that the plain lacquered articles are almost exclusively manufactured by one set of workmen, who supply the workers in gold lacquer with the articles ready for the application of the gold powdering, various patterns, etc.

GOLD LACQUER.—Among the tools and materials used in the manufacture are :—

Neji-fude.—Brushes made of rats' hair, used for tracing out the patterns, and for drawing the very fine lines, etc. The best are made of the long hairs from the backs of "ship rats," whose fur is not so likely to get rubbed.

U-no-ke-usuji-fude.—Fine brushes made of hares' hair. These are a little larger than rats'-hair brushes, and are used for filling in the patterns of the best articles, also for drawing outlines on common articles and ground work. There are 2 sizes, *Dai* and *Sho*, used

for drawing "large" and "small." There are, besides, 5 sizes of *Ji-nuri-fude* (grounding-brushes).

U-no-ke-hake.—A flat brush made of hares' hair, used for spreading the lacquer on large pieces of work. There are 2 sizes used.

Men-sō.—A stiff brush made of deer's hair, used for applying the *Sabi*, etc., in making raised gold lacquer. It is only employed for stiff mixtures.

Hakĕ.—Flat brushes of human hair, for smoothing the lacquer after application, as in ordinary plain lacquer. There are 2 sizes used.

Bun-mawashi.—Compasses with fine brush attached for describing circles.

Kĕ-bo.—Brushes made from the long body-hairs of a horse, used for smoothing the fine gold powder and brushing off extra particles, as also for dusting. There are 4 sizes.

Fude-arai. — Brush-cleaner, made either of ivory or tortoiseshell. The brushes have to be very carefully cleaned, after using, with *Sesamum orientale* oil, to remove every trace of lacquer.

Tsutsu.—A quill from the wing of a swan or crane, over one end of which is stretched a piece of silk, used for scattering the gold dust. There are 2 sizes used.

For applying *Nashiji* or *Hirame*, bamboo tubes of 3 different sizes are used, with silk of more open texture.

Saji.—Spoon, for putting the gold-dust into the quill or bamboo tube.

Hirame-fude.—A pointed piece of bamboo or other wood, used for picking up and applying *Hirame*, or the gold, or shell-squares.

Kujira-bera.—Whalebone spatula. Used for mixing the materials, and also when transferring the tracing on the paper to the article to be painted (process described farther on). The kind used is called island whalebone, and comes from China; that obtained from Japan is practically useless, being liable to split. Two sizes are used.

Hera.—Spatulas made of *Hinoki* (*Chamæcyparis obtusa*), smaller than those used by workers in plain lacquer. There are 3 sizes used for applying plain lacquer, and 3 for applying *Sabi*.

The tooth of a fish, ordinarily the *Tai* (*Cerranus marginalis*), fastened with lacquer on to a piece of bamboo, used for polishing such crevices as are too small to admit of charcoal, etc., being employed.

A piece of polished shell, used for smoothing the paper on which the pattern is drawn before tracing with lacquer.

Tsume-ban.—A palette, made either of tortoiseshell or buffalo-horn, worn on the left thumb.

Take-ban.—A small bamboo board, used when cutting the gold and silver foils into squares.

Gold and Silver Dust used for Ornamentation.—Of these there are several kinds, viz.: *Yasuri-ko* or *fun* (file-powder), made of *Yaki-kin* (pure gold), *Koban-kin* (10 parts gold to $2\frac{4}{16}$ silver), and *Gin* (silver). There are 12 qualities of each, differing in fineness.

Besides these, there is an extra large kind, used for ground-work, called *Hira-me* (flat-eye). The coarsest filings, whether of pure gold, *Koban*, or silver, are taken and rolled out flat on an iron plate. Of *Hirame* there are 8 kinds each.

Next comes the sort called *Nashiji*, from its resemblance, when applied to the article, to the rind of a pear. *Nashiji* is used for ground-work, in making which pure gold, also *Koban-kin* (10 parts gold, $2\frac{4}{16}$ silver), *Jiki-ban* (10 parts gold, $3\frac{1}{16}$ silver), *Nam-ban* (10 parts gold, $3\frac{4}{16}$ silver), and silver of seven qualities of fineness each, are used.

Aka-fun (red powder) is vermilion mixed with pure gold, *Koban-kin*, and silver, for shading.

Kuro-fun (black powder) is camellia-charcoal powder mixed with pure gold, *Koban*, and silver.

Giyōbu nashiji is the coarsest kind of *Nashiji* made, but it is little used, as it requires 7 or 8 coats of lacquer to be applied before it is covered sufficiently to stand polishing.

Keshi-fun.—This is the finest kind

used; it is only made in pure gold and *Koban*. This is made by mixing gold-leaf in liquid glue till it is reduced to an impalpable powder; water is then added, and when the gold sinks the liquor is poured away. This is repeated till all the glue has been got rid of.

Shaku-dōfun.—A mixture of 7 parts pure gold and 3 of copper powder.

Kana-gai.—Foil made of pure gold, *Koban*, and silver. It is made of 4 thicknesses in each quality, viz.: *Honneji*, *Chiu-neji*, *Usushu*, *Kime-tsuke*, the last being the thinnest.

Besides the above, there are several mixtures, as—

Kuri-iro-fun (chestnut-coloured powder).—A mixture of one-half gold-dust with powdered camellia-charcoal and vermilion.

Nedzumi-iro-fun (rat-colour grey). A mixture of half silver and powdered camellia-charcoal, and a little vermilion.

In each case it is evident that several distinct shades can be obtained according as more or less colour is added to the gold and silver dust. It is a remarkable fact that no vegetable colours can be used with lacquer. They are all eaten up, as it were, by the lacquer, and disappear, which accounts for the very few variations seen in the colours of lacquer. The workmen have never been able to produce white, purple, or any of the more delicate shades.

Of late years, since cheap work has been introduced, the custom of using tin-dust has been adopted for making common *Nashiji*. It is manufactured of the same sizes as in gold and silver, and when plenty of gamboge is mixed with the lacquer to cover it, an inexperienced person might easily mistake it for gold when the ware is new; but it soon deteriorates. Burnt tin-dust is also sometimes used for under-coats in making cheap raised lacquer.

Mode of making Gold Lacquer.—*Togi-dashi* (bringing out by polishing).—The article having been subjected to the first 22 processes, as described in making *Honji* (Class I,), is then treated as follows:—

The picture to be transferred to the article is drawn on thin paper, to which a coating of size made of glue and alum has been applied—that known as *Minogami* is best. The reverse is rubbed smooth with a polished shell or pebble, and the outline is very lightly traced in lacquer, previously roasted over live charcoal to prevent its drying, with a fine brush made of rats' hair. The paper is then laid, with the lacquer side downwards, on the article to be decorated, and is gently rubbed with a whalebone spatula wherever there is any tracing, and on removing the paper the impress may very faintly be perceived. To bring it out plainly, it is rubbed over very lightly with a piece of cotton-wool, charged with powdered white whetstone or tin, which adheres to the lacquer. Japanese paper being peculiarly tough, upwards of 20 impressions can be taken off from one tracing, and when that is no longer possible, from the lacquer having become used up, it only requires a fresh tracing over the same paper to reproduce the design *ad infinitum*. This tracing does not dry, owing to the lacquer used for the purpose having been partially roasted, as previously mentioned, and can be wiped off at any time.

The next process is to trace out the veining of the leaves, or such lines to which in the finished picture it is desired to give the most prominence, and these lines are powdered over with gold-dust through a quill. The qualities called *Mijin*, *Koma-kane-mijin*, and *Aragoku*, are generally used; either finer or coarser qualities cannot be used. The article is then set to dry for 24 hours in the damp press. The outline is now drawn carefully with a rat's-hair brush over the original tracing-line with a mixture of black and branch lacquer, called *Rō-sé*. The whole is then filled in with *Rō-sé* applied with a hare's-hair grounding-brush. Gold-dust of a slightly coarser

quality than *Mijin* is scattered over the lacquered portion, and the article is set to dry for 24 hours. Another thin coating of *Rō-se* lacquer is again given to the gold-powdered portions, and the article is set to dry for 12 hours. Next, a coat of *Rō* (black lacquer) is applied over the whole surface of the article, which is set to dry for at least 3 days. It is then roughly ground down with *Magnolia* charcoal, the surface-dust being constantly wiped off with a damp cloth till the pattern begins to appear faintly. Another coating of *Rō* lacquer is then given, and the article is set to dry for 36 hours. It is again ground down with *Magnolia* charcoal as before, this time till the pattern comes well out. The ensuing processes are the same, from 28 to 30 inclusive, as in black lacquer (*Honji*).

In making *Togi-dashi* on hard woods, transparent lacquer is used instead of *Rō*.

Hira-makiye (flat gold lacquer).—The article having been thoroughly finished, either in black or red, etc., as already described under the head of *Honji*, Class I., and the following kinds, a tracing is applied to the surface as in *Togi-dashi*, the outline is carefully painted over with a fine brush of rats' hair, and then filled in with a hare's-hair brush, using *Shitamaki* lacquer (branch lacquer and red oxide of iron). Over this surface gold-dust (of the quality called *Aragoku* being generally used) is scattered with a brush of horse's hair (*Kebo*) till the lacquer will not absorb any more. The article is then set to dry for 24 hours. A thin coating is next applied over the gold, of transparent lacquer or *Yoshino* lacquer, and it is set to dry for 24 hours at least. It is then most carefully smoothed with camellia-charcoal, and finally polished off with *Tono-ko* and a little oil on the point of the finger, till the ornamented portion attains a fine polish. The veining of leaves and the painting of stamens, etc., of flowers, or such other fine work, is now done with a fine rat's-hair brush charged with *Ke-uchi* lacquer over which fine gold-dust (*Goku-mijin*) is scattered from a brush of horse's-hair (*Kebo*), as before, and the article is set to dry for 12 hours. Some *Yoshino* lacquer is then applied to a piece of cotton-wool, and rubbed over the whole surface of the box or other article, and wiped off again with soft paper. It is set to dry for 12 hours, after which it is polished off with deer's-horn ashes and a trifle of oil. When very high-class work is desired, *Yoshino* lacquer, to which a little water has been added, is applied, and polished off a second time, and a very brilliant surface is attained.

More ordinary "flat gold lacquer" differs in the manufacture as follows: The tracing is accomplished in the same manner, but *Shitamaki-nobe* lacquer (branch lacquer, red oxide of iron, and camphor) is used for filling in the pattern with a hare's-hair brush. The article is then set to dry in the press for 10 to 20 minutes, during which time the lacquer has begun to harden, and less gold will adhere. Then gold-dust (*Goku-mijin*) is applied with cotton-wool thinly, and the article is set to dry for 24 hours. The whole surface is then smeared over with *Yoshino-nobe* lacquer (*Yoshino* lacquer and camphor) on a piece of cotton-wool, and wiped off again with soft paper. The reason is that it is less trouble to smear over the whole surface thinly, and it is, moreover, not necessary to give a thick coat of lacquer to the decorated part, as the gold-dust has been very thinly applied. It is set to dry for 12 hours, and ground smooth with camellia-charcoal, and polished with powdered whetstone and oil on the point of the finger. The fine lines are then drawn with a rat's-hair brush charged with *Shitamaki* lacquer, and sprinkled with gold-dust (*Goku-mijin*) from a brush (*Kebo*), and the article is set to dry for 12 hours. The whole is again smeared with *Yoshino-nobe* lacquer and carefully wiped off again with paper, and set to dry for 12 hours. The article is then polished

with powdered whetstone and oil on the point of the finger; and a second application of *Yoshino-nobe* lacquer with a little water, wiped off with soft paper, set to dry for 12 hours, and finally polished off with deer's-horn ashes and oil on the finger, finishes the operation.

Should it be required to make any dark spots or lines, such as birds'-eyes, or to draw human hair, etc., or other shading, this is done last of all with *Kuma*, "bear" lacquer, *Jō-hana*, and lampblack.

More common kind of Flat Gold-Lacquer Painting.—Instead of tracing the design in roasted lacquer, it is done with a mixture of powdered *Tono-ko* and water, and the impression is transferred to the articles with the whalebone spatula as before. The reason for only using *Tono-ko* instead of lacquer is that the ground-work being inferior, it cannot be ground or smoothed afterwards, and the edges of the pattern would not be clean, nor stand out clear, should any lacquer get smeared outside the tracing-line. The outline is then filled in with *Shitamaki-nobe* lacquer with a coarse hare's-hair brush, and the article is set to dry for 20 minutes, or till a thin skin has formed on the lacquer, and then the half-dry surface is wiped over with cotton-wool charged with *Keshi-fun*, the finest gold-powder, and set to dry for 5 or 6 hours. The whole surface is then smeared with *Yoshino-nobe* lacquer, which is carefully wiped off again with soft paper, and the article is set to dry for ½ day. The surface is then rubbed over gently with deer's-horn ashes and soft paper, to give it a polish, and to get rid of any of the last coat of *Yoshino-nobe* lacquer.

The fine lines are now drawn with a fine hare's-hair brush charged with *Shitamaki-nobe* lacquer, and the article is set to dry for 20 minutes or so; then *Keshi-fun* is applied with cotton-wool, and again set to dry for 5 or 6 hours. No further process takes place.

Taki-makiye (raised gold lacquer).—The ground-work may be either black or coloured lacquer, *Nashiji* (pear basis of gold-dust), or the plain wood. The outlines of the pattern are transferred to the surface of the article in the same manner as in *Togi-dashi*, or "flat lacquer." The outline is then painted over with *Shitamaki* lacquer, and this is covered with powdered camellia-charcoal. If the outside is to be higher than the inside, a broad margin is painted and covered with charcoal-powder, leaving the centre untouched, and, *vice versâ*, if the centre is to be higher, a faint line only is painted outside, and the inside is given a thickish coating, which is sprinkled with the charcoal-dust, and the article is set to dry for 12 hours. When taken out of the press, it is well dusted to get rid of any loose charcoal-powder, and is also washed, using a brush made of human hair (*Hake*) to clean out all the crevices and bring out the lines, etc. Some *Yoshino-nobe*, or "branch lacquer," with camphor, is now rubbed on with a piece of cotton-wool, and carefully wiped off with soft paper, and the article is set to dry for 12 hours. The raised parts are next carefully ground smooth with a piece of *Magnolia* charcoal, and a second coat of *Yoshino-nobe*, or of "branch lacquer," is applied as before, and dried.

If a well-raised pattern is required, 1, 2, or even 3 coats of *Sabi* ("branch lacquer" and *Tono-ko*) are applied, the outside edges being painted with a brush of deer's hair (*Menso*), and the inside lacquer applied with a small *Sabi* spatula, the article being set to dry after each application for 12 hours. For coarser work, it is then ground smooth with a white whetstone, and for finer work with a yellow whetstone. Over this some "branch lacquer," mixed with camphor, is rubbed with cotton-wool and wiped off with soft paper, and the article is set to dry for 12 hours.

If the pattern is not to be very high, the operations described in the last paragraph are omitted. A coating of *Taka-maki* lacquer is now given, the outside edges being carefully drawn with a rat's-hair brush, and the inside

of the pattern filled in with a hare's-hair brush, and the article is set to dry for 36 to 48 hours. When taken out of the press, the surface is ground smooth with *Magnolia* charcoal, and then partly polished with camellia-charcoal on a cotton cloth. A little oil is now rubbed on, and a further polishing takes place with powdered "whetstone" on a cloth. Next, "branch lacquer" is rubbed over the raised parts with cotton-wool and wiped off with soft paper, and the article is set to dry for 12 hours. It is next polished with deer's-horn ashes and a little rape-seed or sesamum oil applied on the point of the finger. Up to this point the formation of the pattern, whether mountains, waves, trees, men, birds, or animals, has been gradually completed.

If small squares of gold-foil (known as *Kiri kane*), or of coloured shell, are used in producing the pattern, they are now applied one by one on the point of a bamboo stick (*Hirame fude*), the spot where they are to be affixed having been smeared with a little *Rō-sé* lacquer to make them adhere. When all that is required has been affixed, a piece of soft bibulous paper is spread over the freshly done parts and pressed very carefully with the finger. This is to get rid of as much as possible of the *Rō-sé* lacquer that is not covered by the gold squares; the article is set to dry for 12 hours, and then the portion where the gold has been applied is gently polished with a little camellia-charcoal on the point of the finger, to get rid of the remainder of the *Rō-sé* lacquer. Shell patterns, and the coarser kinds of gold-dust that may be required, are applied in the same manner. The finer kinds of gold-dust are applied next over a coat of *Shitamaki* lacquer, and the article is set to dry for 12 hours. The remaining processes of polishing, drying, etc., are the same as in first-class "flat gold" lacquer.

For making raised-lacquer patterns on plain wood the whole surface is covered with tin-foil, stuck on with rice-paste, to keep the wood quite clean, and then the place only where the pattern is to come is cut out. In making all high-class lacquer, the edges of every article are pasted over with tin-foil to prevent their being rubbed or injured by the workman, and the same is done over each portion as it is finished.

The above is the ordinary method of making best raised lacquer, but from a glance at specimens it will be seen that there are such innumerable modifications of one process or another, according to the object to be produced, that it is manifestly impossible to do more than give the above cursory sketch. Nearly every piece of good lacquer made exhibits a specimen of each kind, viz., *Nashiji*, *Togi-dashi*, *Hira-makiye*, and *Taka-makiye*.

In making raised lacquer on inferior articles, the methods do not vary much from the good kinds; the work is merely less carefully executed. The saving is in the quantity and quality of the gold-dust used, and the absence of minute after-work, or in the use of silver and tin instead of gold-dust. In the very cheapest kinds, burnt tin-dust is used instead of charcoal over the first coat of *Shitamaki*. This is burnished bright, and over it a thin coating of lacquer and gold-dust is applied. At first it looks well, but loses its colour in a year or two. By using tin-powder the same height is attained in 1 coat that would necessitate at least 3 coats of lacquer and charcoal-dust. This kind of work is, however, only used for cheap articles for foreign export, and has been quite lately introduced.

LACQUERING ON METAL.—For lacquering on iron or copper, brass or silver, the metal is smoothed and polished, and then given a coating of "crude lacquer" or "black lacquer"; the article is put over a charcoal fire, and the lacquer is burnt on to the metal till all smoke ceases to escape. The fire must not be too fierce, and the metal must not be allowed to get red-hot, or the lacquer turns to ashes. After the lacquer has burnt quite hard

the surface is rubbed smooth with *Lagerstrœmia* charcoal; these operations are repeated 3 or 4 times, till a good foundation of lacquer has been obtained. Then the same operations exactly are repeated as in making best "black lacquer," *Togi-dashi*, "flat gold lacquer," or "raised gold lacquer," only that the lacquer is burnt dry over the fire instead of being dried in the press. The lacquer is thus rendered quite hard and very durable. After the first 2 or 3 coats have been burnt on, the subsequent drying processes can be carried on in the damp press, should it be so desired.

In winter, or when any article is required in a hurry, the workmen sometimes put a charcoal fire in the press, over which a pan of hot water is placed. The steam which is thus generated helps to dry the lacquer in an hour or two, which would take 24 hours to harden ordinarily, but the lacquer thus dealt with loses its strength, and is never very hard. "Black lacquer" turns a rusty brown, the colouring virtue of the iron being apparently lost, and therefore this plan is never adopted for good work, and in second-rate work only for under-coats.

NASHIJI (Pear Basis).—This style of ornamentation, occupying an intermediate position between plain and ornamental lacquer, is treated of last. Till the opening of Japan to foreign trade, it was in the hands of workers in gold lacquer, but now for the most part all *Nashiji* on articles intended for exportation is applied by workers in plain lacquer. In making best *Nashiji*, as in *Togi-dashi*, the first 22 processes are identical with *Honji* (Class I.). A coating of *Rō-se* is applied, and the gold-dust is sprinkled over the surface through one or other of the bamboo tubes, according to the fineness required. The article is set to dry in the press for 48 hours, and is then given a coating of pure transparent varnish. This is set to dry for 3 or 4 days, when it is roughly ground with *Magnolia* charcoal, and a second coat of transparent lacquer is given. The article is set to dry for 48 hours, and then ground with *Magnolia* charcoal till a perfectly smooth surface is obtained. Transparent lacquer is then applied with a piece of cotton-wool, and wiped off again with soft paper, and the article is set to dry for 24 hours. It is then polished with a mixture of *Tono-ko* and camellia-charcoal powder and a little oil. Next, a coating of *Yoshino* lacquer is given, and wiped off with paper; the article is set to dry for 12 hours, and then it is polished with deer's-horn ashes and oil. This is repeated 3 times to finish the article.

The same processes are gone through when using silver instead of gold dust.

For cheap qualities, tin-dust is used, and the powder is scattered on glue immediately above a coating of *Kanoji* (whiting and glue). When the article is dry, it is burnished with *To-kusa* (*Equisetum*), and as soon as it presents a bright surface a coating of pure transparent lacquer, with gamboge, is given to it. It is set to dry for a day in the press, and ground with *Magnolia* charcoal. Over this a coating of *Shu-urushi* (transparent varnish containing oil) is applied, and another drying for 24 hours completes the process. (J. J. Quin.)

To Clean Lacquered Articles.—First boil the articles in a pan with ordinary washing soda to remove the old lacquer: then let them stand for a short time in dead aquafortis, and after run them through light dipping aquafortis. Swill all acid off in clean water, and lighten any parts in relief with a steel burnisher, wash again in clean water, and dry out in beech sawdust. Next place your work on a stove, till so hot that you can just bear to touch with your hand, and apply pale lacquer with a brush. The work must not be made too hot or heated too rapidly or it will burn.

LANTERN SLIDES.

(*See also* DRAWING AND WRITING ON GLASS, ETC.)

IN the making of lantern slides there are three methods, viz. (1) that of photography, in which the slide is a positive (on glass) printed from a suitable negative, and which may be left plain or afterwards coloured; (2) the drawing and painting of a picture on glass, and (3) the making of black outline drawings or sketches to illustrate mechanical details in technical lectures. The preparation of slides of microscopical objects does not come within this article.

The Preparation of Slides on Sensitised Glass from Suitable Negatives.—When using purchased plates, attention should be given to the makers' directions for exposing and developing. These goods commonly require a little different treatment to ordinary negative plates or bromide paper, and many are spoiled through giving no thought to this.

Printing Frame.—To print transparencies for the lantern by contact, when the negative is of a larger size than the picture required, necessitates some special kind of printing frame, if the negative is to be kept free from scratches. The following may be simply made, and will be found a great convenience where a number of pictures are required alike: Take an ordinary printing frame, say a 12 by 10, of the kind made to use without a plate-glass in front, and in the rebate where the negative is usually placed fasten, with strips of paper all round the edges, a piece of very flat glass; turn the frame over, and on the other side of the glass fasten a mask of paper or cardboard having an opening 3¼ in. by 3¼ in. exactly in the centre. Now, in place of the ordinary hinged back, make a frame of the same size and thickness, with an opening in the centre about 6 in. by 4 in., and cover all over one side, with the exception of the opening, with a piece of velvet. This frame, when placed in position, will be held by the springs that originally held the hinge back. To complete the arrangement, cut out a piece of dry mahogany 1 in. thick, and exactly 6 in. by 4 in. to accurately fit the opening in velvet covered board, and on this block draw a square 3¼ in. by 3¼ in. exactly central. At one end of this square glue down a very thin slip of hard wood—that is, rather thinner than the glass plates to be used—and at the other end cut a mortice 3¼ in. long, and about 1 in. wide, right through the block, beginning just within the 3¼ in. line, say $\frac{1}{16}$ in. less. Into this mortice fit a piece of wood 3¼ in. by 1 in. by ½ in. On to one side of this piece glue a similar strip of hard wood to that placed on the end of the block only, projecting ¼ in. each end, and on the other side screw a similar piece so that it can be removed. Place the piece in the mortice, and screw on the back slip of wood; there will then be left a space of ½ in. at the end, just room to put a piece of bent steel clock spring sufficiently strong to clip the 3¼ in. plate in position. The sides of the block may be rebated down ½ in. at the 3¼ in. line to allow the thumb and finger to adjust the plate in exact position. To complete the frame, place the block in the opening of velvet board, and arrange an ordinary brass pressure frame spring to keep it in position. For use, take the frame, remove the board, and adjust the part of negative required over the 3¼ in. opening, then place over the velvet-covered board, and fasten down the springs. The 3¼ in. plate is now clipped in the block, and dropped carefully into the opening over the negative, and after exposure is lifted out in the same way, so that any number of exposures may be made exactly registered in the same position, without the chances of injury to the negative which often occurs unless some such arrangement is adopted. (A. Cowan.)

Size, Shape, and Mounting.—The

size generally adopted for a lantern slide is 3¼ in. square, with ½ in. margin, which gives the sight of the picture 2¾ in. square. By "square" I mean the so-called cushion shape—that is, square, with the four corners rounded. All lanterns of any pretensions are fitted with condensers of 4 in. diameter, and this will take nicely the shape above-named without any falling off at the corners, the diagonal of the opening of the masks for the purpose being 3¾ in. If the lantern is fitted with condensers of 3½ in. diameter only, masks with round openings can only be used for all pictures, unless one is satisfied with only small-sized pictures. As regards condensers, many of the modern lanterns are fitted with condensers made with two plano-convex lenses, mounted with their convex sides to each other, and the two plano surfaces outwards. For limelight, a condenser of this kind is the *worst* form, as it is almost impossible, when centring the light (especially when the mixed jet is used, where the light emanates from a very small spot only), to get a perfectly flat field, or "depth of focus"; and the adjustment of the light requires to be very accurate or the disc is not perfectly white. Not so if the other form of compound condenser be used, made up of a bi-convex lens, and the other lens of a meniscus form; and when mounted, the side which is concave being towards the light, and the convex side towards the screen. A condenser of this kind always gives the best results with the mixed jet. The defect in the first-named condenser is not so great if the safety or blow-through jet is used, as the spot of light on the lime is much larger; and the defect is still less in the oil lantern, as the size of the flame is still larger. The plano-condensers are used as being much cheaper.

To avoid mistakes, the masks for lantern slides are best made of what is known in the paper trade as surface paper—that is, paper black one side and white on the other, the black side being placed towards the film, and the white side towards the cap glass, and on this white side of the paper the name of the subject can be written with pen and ink. The white side is also very convenient, as it can be easily seen in a very dull light by the operator. In making slides for amateurs, I generally mount them in this way; but I think a more elegant way is to use masks black on both sides, and write the title in white with a pen. To do this, get a bottle of Chinese or permanent white, empty the contents into a much larger bottle, and thin down with water, stirring well with a piece of stick kept for that purpose, to a consistence that will flow in an ordinary fine-pointed pen. Or, if the title is long, it is best to use a steel pen called crow-quill size, or a lithographic pen; the writing is then quite as easily done as with an ordinary pen and ink. The white must be occasionally stirred or shaken up, as the pigment being heavy soon settles.

Whichever system of mounting is used, the white side, or where the title is written, this side always goes to the light, unless the pictures are to be seen by the audience on the other side of the sheet, then matters are reversed, and the white or written side of the slide must go towards the sheet.

The shape of opening of the mask is a matter of taste and judgment according to the subject; for ordinary landscape or interiors, the cushion shape will generally be found the best, except in some instances where there is something objectionable in the corners, then a circular opening may be an improvement. Or take the subject of a distant landscape with too much of a grassy field in the foreground, the circular shape decidedly will be a very great improvement; in few instances an oval will be a greater improvement still. For portraits the oval form is far superior to any other.

In many instances, the square or cushion shape is not suitable to the subject, especially where slides have to be made from negatives not taken for that purpose. The 7½ in. by 5 in.

and the 7½ in. by 4¾ in. size negatives, are mostly very unsuitable to contract into a square shape, unless the sides contain unimportant matter and can be cut off; if the whole of the subject has to be included, it is better to make a mask of the same proportions. In some instances, the sky can be made higher; if the subject be a flat country scene, then the sky being made higher will give a better representation of the flat or marshy country; but if the subject be mountain scenery, making the sky higher would have the effect of dwarfing the mountains, which would not be truthful; just the same as in mounting an ordinary portrait, the higher the subject is mounted the taller he or she looks, and the lower the shorter, and it is just the same with the landscape subjects before alluded to. Many pictures are entirely spoiled by injudicious mounting, whereas, with a little care and taste, their value would be greatly enhanced. The masks I use I generally purchase by the gross, of the standard sizes, taking care that they are accurately cut and not out of the centre; and for odd sizes I have a lot of shapes made of hard sheet brass, 3¼ in. square outside, with the various sized openings, using the Woodbury cutter, which is very easy, cutting on a piece of plate-glass.

As to the binding of slides, nothing is better than *thin* black paper—not the ordinary so-called needle-paper that is generally used. The thicker the paper the more easily it is pushed off. Many use gum to stick it on with. Paste with the thin paper sticks far better than gum. The heat of the lantern makes the gummed paper tumble off the glass, whereas it has no effect, if paste is used. To make the binding more durable, if a little trouble is not an object, and the thin paper is used, just pass a camel-hair brush, charged with ordinary negative varnish, over the paper, which makes it very hard, and stand a lot of rubbing without getting damaged. (W. Brooks.)

The Use of Dry Plates.—(*a*) All the manipulations can be carried on in the evening, with much greater rapidity, as well as economy, than any other method of producing pictures. A perfect lantern slide must possess two qualifications, viz. clear glass in the high lights, and, when held up to the window with a ground glass or other suitable background, full and distinct details in the shadows. For contact printing (which is the method largely practised), the following should be provided: One glass pan (4 by 5) for developing; two glass pans (5 by 7); as these will hold two plates each at a time, they will often be found useful when fixing and clearing. It frequently happens that the first plate is not entirely fixed by the time the second is ready to be placed in the hypo.; hence a large tray is quite essential. One deep printing frame. A student or other kerosene lamp, with a porcelain shade, is the best for making the exposure, and a developing lantern yielding plenty of diffused orange-coloured light is essential for the dark room. In the dark room the negative is now placed in the printing-frame, and the box of sensitive plates is opened; one is then laid upon the face of the selected portion of the negative most suitable for a slide. Next hold the frame up in front of the orange-coloured lantern, to obtain the correct adjustment of the slide with reference to the picture, and carefully keep the plate in position while laying the frame down to put in the pressure board. It is now ready for exposure, which should be made with a frame fixed at a distance of about 12 in. from the lamp. Considerable latitude is allowable in the duration of the exposure, provided the developer is made to correspond to it. A long exposure, 15–40 seconds (according to the density of the negative), with a dilute developer is the most suitable, yielding warm brownish tones with fine detail in the shadows.

Abandoned negatives, with the film cleared off by boiling in water, can be utilised for the protecting glasses by being cut up to the proper size. Care

should be taken to use glass free from spots or bubbles. (J. E. Brush.)

Making Outline Drawings on Glass Slides to Exhibit Mechanical Details.—As the lantern is largely used at technical lectures, it may be explained that there is a very simple means of making slides to exhibit details of mechanism, piping, mathematical problems and the many things that the lecturer alone has a use for, and that perhaps for one occasion only. All that is needed are some squares of ground glass (ground on one side only as usual) to make the required number of slides, and on the ground surface of these, with a hard lead pencil, the required drawings are made. When the detail is finished a coat of varnish is spread over and *this converts the ground glass into clear glass with a fixed drawing upon it.*

Colouring and Painting Lantern Slides.—(*a*) Use transparent colours, namely, prussian blue, gamboge, carmine, verdigris, madder brown, indigo, crimson lake, and ivory black, with the semi-transparent colours, raw and burnt sienna, and vandyke and cappal brown, thinning oil colours with ordinary megilp to a degree just sufficient for proper working, and using for a medium for laying on the first coat of water colours gelatine thoroughly dissolved and hot. When perfectly dry this coat can be shaded and finished with water colours mixed in the ordinary way with cold water; but the manipulation of the added colours must be gentle, so as not to disturb the layer first put on the glass. A thin coat of the best mastic varnish heightens the effect of shades painted in water colours, but oil colours require no varnish.

(*b*) Having failed in getting results to please myself by dabbing, stroking, and many other dodges, I have now succeeded in getting perfect gradation of tone by pouring on a filtered solution of colour, previously ground up with "medium," in an agate mortar. Pour it on very dark at the top of the picture and flow it down to the horizon, then back again slowly, and allow it to drain off at the edge; when the proper depth is attained, blot off the drainings from the edge; when dry, the outline of the horizon is easily obtained sharp by rubbing off the paint which has run over the border with a fine paper stump. Should any dust settle in spite of all precaution, make your clouds at the faulty part, thus getting rid of specks. (G. Smith.)

My troubles began in slide painting in making a sufficiently fine outline; and this is how I overcame this difficulty, and hit upon a plan at once as good, if not better, than that given by Dallinger of drawing on ground glass with a pencil: I first hunted up an old round table; this I painted a dead black colour, smoothing it off with sandpaper and filling up all cracks; then another coat of black, with plenty of turps in and a few pinches of vermilion to take off any tendency to blue in the paint. When thoroughly hardened, you have a circular black-board, upon which you may sketch your intended outline. With a white chalk crayon, work as many fine outlines as you think proper. I then from this took a negative with an instantograph, using the 3¼ in. by 3¼ in. prepared "lantern dry plates" of Lancaster, giving about 5 seconds in dull weather, and developed until the black table began to show the merest trace of darkening: then I worked off and fixed and dried. I then had a most beautiful outline of the subject I wished, and done in ¼ the time it would have taken me to draw on the glass direct, and far better, and shows beautifully on the screen. Any amount of detail can be quickly done on the round black-board, with the positive assurance that it will show well when magnified. (H. Green.)

(*c*) Having prepared two pieces of wood—one of them having a long tapering point, that of the other being more obtuse and of dimensions suitable for being easily held by the fingers—wrap tightly round them a small piece of thin washleather. They will then pre-

sent an appearance suggestive of crayon stumps. I would recommend the beginner in this art to procure a number of good engravings of landscape scenery having a nearly uniform sky with a few light clouds; because, if he study these, he cannot fail to acquire a good idea as to the forms of, and effects produced by, such clouds. It will be well for him to practise with a pencil and a sheet of paper those forms best adapted for the special picture on which he is engaged. Having thus previously determined upon the nature of the clouds—confining himself at first to those white fleecy ones which are so frequently seen floating across a clear blue summer sky—let him apply the larger of the stumps, and, with a motion conforming to the curling outlines of the cloud, remove the sky-paint. There is room here for great artistic display; indeed it is nearly the only stage in the whole course of painting a photographic transparency in which artistic taste can be shown. I have seen a transparency-artist point a common match with a penknife, wrap round it a bit of thin washleather, and in less than a minute pick out clouds in a picture, which no amount of protracted labour could have improved upon. I called it "genius": he said there was no genius in it, other than that which was the result of study and practice. In many cases the mere suggestion of a cloud proves effective. Let the upper edge be clean and sharply cut, and avoid the bad taste of bringing the cloud up near to the projecting tree or spire and then breaking it off suddenly. Carry it boldly across the projection, which quite ignore. The advantage of doing so will be found when at an afterstage the colour is removed from the spire, by which the sky is thrown back, the other being brought near. It is so easy to clean off the sky with the stump, that the tyro is often tempted to overdo his clouds; hence he must be cautioned against this. I have spoken of pure white fleecy clouds; at a more advanced stage he must try to back up the silver edges of his clouds with a more materialistic colour. For this purpose a little Payne's grey, warmed with rose madder very sparingly applied, will produce a good effect. It is not easy to impart a knowledge of cloud-making altogether by precept, so I would recommend the pupil to purchase a few well-painted slides, and observe the special means employed to obtain such effects as are produced. The sky being completed, remove by means of the fine stump all paint from the distant hills, trees, spire, and indeed from every portion of the picture except the sky. If there are distant mountains colour them with crimson and raw sienna, or crimson and blue, according to their nature, keeping carefully to their outlines. Observe that no dabbing need be had recourse to when painting the rest of the picture unless it be a subject in which there is a smooth, unbroken portion, such as a lake or the sea. As this is supposed to give a reflection of the sky, it must be painted in a similar manner. Observe, also, that every portion of the picture must be painted stronger and in brighter colours than would be the case were it a small picture which was to remain and be viewed as such, because by magnifying a 3-in. picture up to 12 ft. the colours become attenuated by the act of enlargement; therefore the colours may be strongly applied, in the certainty of their being toned down when projected on the screen. To return to the mountains; while the distance is warm and of a ruddy purple, keep the shadows cold especially in the nearer ones. When painting the mountains, avoid using the brush in such a way as to cause a ridge of paint to form an outline, but as far as possible work the brush from the margin inwards. By doing so, the sky is left undisturbed. This also applies to trees. For these a green is employed composed of gamboge and prussian blue. This will answer for the greater number of subjects in which there is foliage; but the addition of crimson lake will be necessary to obtain such warmth as that asso-

ciated with autumnal tints. There are some specimens of foliage which may be fittingly coloured by lake and gamboge alone; but a judicious mixture of the colours mentioned will serve every purpose. It is not as if the painting were being made on clean or transparent glass. Here the foliage is composed of shades more or less dark, and, what is of importance also, of a tone that may range anywhere between a warm ruddy brown and a cold black, according to the method adopted by the photographer in toning. And this renders it impossible to say definitely what pigments ought to be employed in painting them. If the foliage be sombre and heavy, the gamboge should then predominate. This applies also to a grass lawn or meadow. All that will be required for the trunk of a tree will be to warm it up with burnt sienna, well thinned. (J. J. Houston.)

(d) When preparing photographic transparencies for colouring, do not treat them in precisely the same way as if intended to be used without colour. If you examine a fine slide, by any well-known maker, embracing rural scenery with much foliage, it will be found that whereas in nature the foliage was green, of a more or less bright hue, in the photograph it is many shades darker than it should be owing to the number and density of the atoms of the silver composing the foliage, this being the case to such an extent as to prevent the green pigment from showing at all.

This is quite a different matter from painting a photograph on paper or porcelain, for in these the blackest shadows or heaviest foliage can be lighted up at pleasure by the use of opaque or body colours, or by mixing a little flake white with the transparent pigments which alone are applicable to transparency painting. But if, in a transparency, recourse were had to this procedure, it would make things worse than before, for the luminous equivalent of flake white when applied to paper is, in a transparency, the thinning of the deposited silver so as to allow more light to be transmitted, the touch of pure white light given to form the highest light in the one finding in the other its equivalent in the complete removal of the image by the needle-point or penknife, so as to leave nothing but bare glass.

To one who has had some experience both in making and colouring transparencies, it is not difficult to obtain the best class of photograph for receiving colours with effect, although it may prove difficult to describe the characteristic features of such photographs. Perhaps the best idea will be conveyed by saying that it ought to be "outlines," and even its outlines should not be too dense. A very brief exposure and rather long development afford the keynote to the nature of the manipulations requisite to secure the best effect.

Having obtained a suitable transparency, it must next be varnished. Some years ago I adopted the use of a varnish composed of sandarac dissolved in methylated spirit. It gave a clear, bright film, and both oil and water colours took to it nicely; but I sometimes had occasion—as every painter of lantern slides will have to do more or less frequently—to pick out bits, and put in, or rather take out, touches of high light by means of the needle-point. I found, however, to my extreme dissatisfaction, that the collodion film would chip and break off round the spot upon which I operated, and that if I drew fine lines by my scratch-point they became jagged and broken. Being recommended to try white hard spirit varnish diluted with alcohol, I did so with a result even worse than before. Having read of the virtues of castor oil when added to a plain sandarach varnish, I tried it with excellent effect.

I have also employed, with the greatest degree of success, a solution of albumen composed of the white of an egg beaten up with twice its volume of water together with 10 drops of ammonia. After the frothy mass has settled, the clear liquid is poured off.

To use it the transparency is flooded with the liquid, which is then drained off at one corner, and the picture immediately immersed in a tray of hot water, the temperature of which is but little under the boiling-point. This coagulates the albumen, leaving it not only of a glassy degree of brightness, but modified in such a manner as to render it unaffected by either water or oil paints, while it is susceptible of the most delicate touches of another class of pigment, which I shall describe before concluding.

The question now arises: What class of colour is best for transparency printing—oil, water, or varnish? This cannot easily be answered; each has its own advocates. They are all good in their way, and there are some transparency artists who employ them all even in one picture. As oil pigments appear to enjoy the greatest amount of popularity, I will speak of them first. Although nearly every dealer in lantern appliances keeps boxes of colours for sale, it will be advantageous, especially for the beginner, to purchase from artists' colourmen, under their definite names, the various colours required. They are conveniently put up in tubes and are sold at a very low price—4*d.* and upward. It must also be noted that only very few pigments can be employed, owing to the paucity of such as are quite transparent; hence the expenditure for an outfit is very small.

For blue, *prussian blue* forms the most useful among all the blue pigments, and one can get along very well indeed without any other, although there are some subjects in which *Payne's grey* comes in handy. There are other transparent blues, such as *Chinese blue* and *cyanine blue*; but the prussian is susceptible of such easy modification by the admixture of others that no other is really required. The best yellows are *gamboge*, *Italian pink*, and *yellow lake*. There is but little difference between the two last, although the former of them is probably the more advantageous. The *gamboge* is useful for foliage, and with a small proportion of prussian blue forms a good green. Both *raw* and *burnt sienna* must be procured. The former is useful in the representation of light, dry, sandy earth, dry roads, and light-coloured houses; the latter is a very transparent brown of an orange tint. Both *vandyke brown* and *burnt umber* are useful, but much less so in a photographic transparency than in other classes of work, because any subjects which were of these tones in nature will be represented so very darkly in the photograph as to require scarcely any colouring at all. *Crimson lake* and *pink madder* complete the list. The latter by itself dries very slowly, but by the admixture of megilp or mastic varnish its drying is quickened. This applies also to the Italian pink. A tube of *lampblack*, by which to render any portion more or less opaque; a tube of megilp, for use as a vehicle; and a bottle of mastic varnish and pale drying-oil, together with a few sable brushes, a palette, palette-knife, and large camel-hair brush complete the outfit.

The most important piece of work in the painting of a lantern landscape being the sky, I close this article by describing how it is done, premising that I do all my painting upon a retouching desk, which I find to answer this purpose rather better than the easels specially prepared for transparency painting. Let us imagine that the subject is a landscape, having about ⅓ sky, into which a tree, and a spire project upward. Mix on this palette a little burnt sienna and pink madder, and having charged a brush with this, draw it in streaks across the sky a little above the horizon, and then laying down the brush, dab it all over with the point of the first or second finger until it presents a uniform appearance. Never mind the fact that the paint has been carried over the tree and the spire; it must be removed from them by a pointed piece of soft wood as the last operation of all. Next apply to the upper

portion of the sky some prussian blue, and in so doing remember that there is no use whatever in hoping or attempting to make it quite uniform by means of the brush alone. The finger is the all-potent instrument by which uniformity is secured, and "dabbing" with it must be had recourse to. Bear in mind that the sky is of a deeper hue at the zenith than near the horizon; therefore let the dabbing be performed in such a manner as to retain more of the paint at the top, than lower down, the quantity being so attenuated by the time it descends to the warm layer already applied as to merge into it quite imperceptibly. The laying on of a uniform coat seems very easy to the onlooker; but it is only by dint of several trials carefully made that success is attained. As the beginner will probably spoil several skies before he succeeds to his own satisfaction, a soft piece of calico dipped in spirit of turpentine will be a useful aid to him during his novitiate.

To complete the blending of the colours, and to obliterate the slight textural markings arising from the roughness of the finger tip, is the function of the large camel-hair brush already mentioned. It must be whisked very lightly over the surface; and, if cleverly done, all surface asperities will disappear, and the colouring look as if the glass were stained. Until the sky presents such an appearance the formation of clouds must not be thought of.

(*e*) Some authorities consider water colours the best with which to colour lantern slides, but the work must be varnished with alcohol varnish to render the colours transparent and fixed. For oil colours copal varnish is the best vehicle, and to use this satisfactorily the oil must be got out of the colour, as much as possible, this being done by letting the thick colour (from the tubes) rest on blotting paper for a time.

(*f*) For drawing and painting on glass for lantern slides first make the design in lithographic ink, worked dry in a cup, then diluted with spirit and a few drops of copal varnish. When the lines are dry water colours may be washed on, the water used for these having 4 parts gum and 2 parts sugar to each 20 parts water with a few drops of phenic acid to prevent mould. When dry and finished, the whole is varnished over with 9 drachms of white gum-lac dissolved in about ¼ pint of alcohol. Warm the glass slightly before varnishing. The protection afforded by the varnish is not always considered necessary when a cover glass is used, but the varnish assists in giving transparency.

(*g*) Water colours for slides should be as transparent as possible, the following being suitable, cochineal carmine, madder carmine, Berlin blue, yellow lake, vegetable green, burnt-sienna. Indian ink for black. Be sure keep dust from the work, as every particle will be visible on the enlarged picture.

(*h*) The glass for the slides must be very carefully selected; it should be plate glass cut to the size of the object glass in the magic lantern in which it is used. It must be entirely free from air bubbles, and streaks of any sort; even the best plate glass has a rough and a smooth side, which can be found out by passing the hand over its surface and so detecting any unevenness. As any irregularities will interfere with the smoothness of the colour to be laid on, the smooth side of the glass must be carefully marked and used in all the plates.

A flat palette is a necessity for oil colours; but for water colours, a palette with a rim to keep in the tints is the best. A palette knife is required for mixing together oils, colours, or varnishes, but is not wanted for water colour slides, except to take out larger lights. A maul stick to keep the hand from touching the wet painting, can be made by covering one end of a light but firm cane with wool so as to form a round knob, and tightly binding the wool over with wash

leather, notching a groove in the cane to render the binding string quite secure.

For brushes, red sable are best, being stronger in their hair than black sable or camel-hair, and they have a firmer and finer point than either of the others; the brushes should be enclosed in flat tin, one of every (6) size.

Dabbers are made by the amateur from round camel-hair brushes; one of each of the 6 sizes is used. The points of the round brushes must be cut off as shown in Fig. 32, the dark

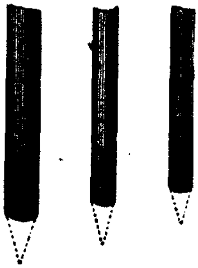

FIG. 32.

lines show the part of the brush to be retained, the white space within the spots the portion to be cut away. In order that the ends cut should be rounded, they must be burnt to shape after cutting, by being held in the flame of a candle. They must be twisted and turned round and round, so as to shape them to the proper form. When this is attained, clean off the traces of burning from them by rubbing them well with the finest sand paper.

When the slide is painted, it requires to be mounted in a frame. These frames are made of wood; mahogany is generally selected, but deal will answer all the purpose. The three shapes for these frames are square, oblong, and round. The wood should be about ½ in. thick, and where the glass is to be inserted, the edge should be bevelled or have a rabbet on one side, the glass should be slipped in on this side, and a tiny steel or brass rim laid over it to keep it in its place. In choosing the wood for these frames, select only that which is perfect in grain and has no knots.

Paint slides by lamp or candle-light as, being intended for exhibiting by artificial light, it will be seen at the time of painting whether the right effect has been produced.

Commence operations by drawing a perfect outline of the picture on a piece of paper, which is laid under the glass as a guide. When a much larger picture than the size of the slide is to be copied, as long as the prominent features of the picture are seized upon, the effect is attained, and one or two accessories will look better than a quantity crowded into a small space.

Should any inaccuracies be found when the outlining is finished, the colour can be removed by the knife. When all the corrections are made, and the outlining is judged complete, it must be fixed to the glass by washing all over its surface a varnish made of Canada balsam, diluted freely with turpentine. Having completed the outline, fixed it with varnish and rubbed up the glass well, proceed to the second painting.

Moonlight subjects can be rendered pleasing if the appearance is given of the clouds moving, or rather sailing past the moon. This is managed by having two pieces of glass where the sky is painted. The wooden frame will have to be double on one side, to contain the fixed piece of glass, and the other to form a groove for the movable piece to rest on. Upon the fixed glass the moon is painted and a light sky without clouds. The movable piece of glass is only a narrow strip, just sufficient to hold the clouds. Fleecy and dark clouds should be painted upon it in such a manner as sometimes to allow the moon to be feebly visible, at others partly or completely obscured. Make these clouds as unlike each other as the narrow strip they are on will allow. Do not leave large spaces in between, and let

the strip they are painted on be of a good length, so as to give greater variety. Have a thin piece of wood fixed to the end of the strip, to serve as a handle, and when the slide is being exhibited insert the strip of glass, and push it slowly along.

This is only an amateur contrivance, but will answer several purposes, especially whenever some small objects are required to move straight along and disappear, while the larger part of the picture remains stationary. A ship as in full sail can be drawn across a sea-piece by this contrivance.

Fig. 33, known as the lever slide, is used when the motion of the movable piece of glass is to be up and down, and not revolving, and is particularly useful for comic slides. Thus a dog killing a rat is depicted in the act by using the lever slide. Paint the dog with the exception of his head and neck, and all the requisite surroundings, upon the fixed glass, and upon the movable one his head and neck with the rat in his jaws. When fixing the slide in the lantern, be careful that the neck on one glass is quite joined to the shoulders on the other, and that the colouring of the animal is exactly similar on both glasses. By working the lever up and down, as shown by the dotted lines in the figure, the head and neck of the dog will be in motion, and the rat will look as if it were being well-shaken. ('Artistic Amusements.')

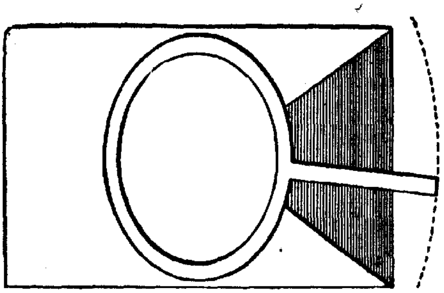

FIG. 33.

The Use of Aniline Colours.—(*a*) Obtain some sample boxes of different aniline colours, such as methyl violet B, naphthol yellow S, naphthol red, orange 2, light green S.F., bismarck brown, methylene blue B, palatine scarlet, vesuvine brown, and sorbin red; these are put up in powder form, and for use must be diluted with hot water, and allowed to cool. Half a salt-spoonful of powder is sufficient to make an ounce of liquid dye. The methylene blue is very strong, and only half the above quantity of powder is needed; it is an excellent colour for skies. Transparent colours made by Günther Wagner may also be used; these can be obtained in liquid form in small bottles costing 6*d.* each; there are twenty-four different colours, those most useful for the special purpose being vandyke brown, neutral tint, Indian red, olive green, sepia, and deep green. Both the aniline dyes and the albumen colours are found to be perfectly transparent. A good sable brush is necessary; a Winsor and Newton No. 6, costing 6*d.*, is all that is needed, from the very finest work to washing in skies. A small porcelain palette and a cheap retouching desk complete the outfit. These colours do not show brush marks and are more suitable for lantern slides

than water or oil colours. (Rev. H. Mudie Draper in 'Focus.')

(*b*) Until recently, coloured lantern slides were invariably painted with oil or water-colour pigments; but the success of the three-colour process with stained films has again drawn attention to the use of aniline dyes as suitable materials for tinting transparencies. Hitherto the chief objection to anilines has been their fugitiveness, and this instability would undoubtedly be a serious drawback if it could not be prevented; but with improved chemical preparations, such as are obtainable to-day, it is possible to get a variety of colours that will stand the test of many years' use in a lantern without fading.

I have some confidence in advising amateurs to try aniline colours, for the use of which the following few and simple directions may be of service:—

1. The slide to be coloured should be placed on a sheet of ground-glass held in the opening of an ordinary retouching desk.

2. With a large brush charged with water and a drop of ox-gall, wash the film over the whole surface. This will remove any greasiness and prevent blisters, which would otherwise occur if only a portion of the film be worked upon without previous wetting.

The film should now present a dull, moist surface without actual wet, and be capable of absorbing colour without any tendency to overrun the boundaries. See that no loose hairs from the brush are deposited.

3. Dilute the colour, if too strong, and get depth by repeated washes, except for small patches, which may be put on full strength, but no wash should be so dense as to clog details.

4. As a rule, the density of the slide itself will yield the blacks, but occasionally they may have to be assisted by colour. There is no satisfactory black amongst the aniline dyes, therefore, for branches of trees, black boots on figure studies, and similar small items, gum-water colour may be used with advantage.

5. If the slide be too pronounced in colour, soaking in water will remove the excess, though this should not be necessary with ordinary care.

6. Dissolve the powder colours in boiling water, not in cold water, and keep them in small bottles. About six or seven colours will be ample.

7. For fine details use a magnifying-glass.

8. Test each slide in a lantern before showing it in public.

9. Work with two brushes, one charged with colour and the other moistened with water for softening the colour, or for absorbing and removing any colour that has been accidentally put in the wrong place.

10. Work quickly, and do not let drops of colour remain on the film before spreading where wanted. (Walter Bagshaw, in the 'British Journal of Photography.')

LEAD BURNING.

THE process of lead burning or autogenous* soldering consists merely of heating the edges of the lead (which require to be joined) until they melt or fuse one into the other. The edges of the two pieces of material, when melted to this extent, readily become incorporated, the same as if two portions of molten lead were poured together. Therefore the object to be attained in this work or process is simple enough, but the actual process or mode of doing it requires both skill and care besides some suitable apparatus.

Lead burning is done without any description of solder or other foreign material; and as a rule no flux is employed. For roof work and for several other purposes burning is preferable to soldered joints in strength and in lasting qualities. When the operation is successfully performed, the work is stronger than when soldered, for all parts of it are alike, and will expand and contract evenly when heated. Solders often expand and contract more or less than the metals which they unite, and this uneven contraction and expansion of the metal and solder may tear the joint apart. Another objection to soldering is that the solders oxidise either more or less freely than the metals, and weaken the joints, as is the case if leaden vessels or chambers for sulphuric acid are soldered with tin. Tin being so much more freely dissolved by the acid than the lead, soon weakens or opens the joints. It is particularly with the many leaden vessels and chambers used in the preparation of chemicals that lead burning is specially useful.

* There is nothing that can be considered of an autogenous nature in this work. It is not a correct name, though largely quoted. It might also be said that lead "burning" is an incorrect term, for the lead is not burned, but only fused or melted where the joint is required. In the original method of burning lead there was no flame employed at all, molten lead being poured on to the seam and afterwards trimmed off.

The apparatus required in the performance of this work consists chiefly of two things. The first is generally known as the lead-burning machine, though it is no more nor less than a suitably constructed vessel for the generation of hydrogen gas.† The second is a bellows or other device for delivering ordinary atmospheric air

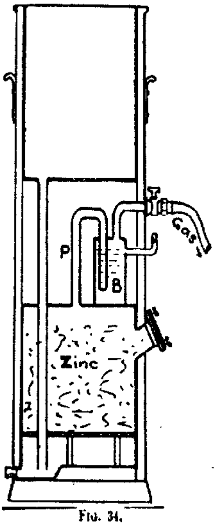

FIG. 34.

under a light pressure. The two things together form a means of making a superior blow-pipe flame.

Fig. 34 illustrates in section the

† The machine makes hydrogen gas on the spot close to the work, and it can be readily moved as required. If, however, ordinary coal gas can be obtained on the premises, this could be used with a suitable burner, and with the bellows for the air supply. Or, again, the cylinders of compressed gases would be superior to all, if the plumber lived or was working near a town where they can be conveniently recharged as required. The machine, however, has the advantage that it can be used for weeks or longer periods without removal from the job, as the materials for charging it can be easily obtained.

form of machine ordinarily used, and which is considered to be free from the many failings that the earlier machines brought to light. This consists of an upper and a lower lead vessel, the upper one open at top (or with a loose cover), the lower one being gas and water tight, except for the necessary openings provided. About 5-lb. sheet lead is used for these (with burned seams and joints), though the stronger the better, except for the weight in transporting the machine. Between the upper and lower vessel is a space containing another small vessel as illustrated. It is highly desirable that the machine have a wood case, or any means may be adopted to prevent it becoming cold; if not, the sulphate of zinc which is formed will become crystallised, stopping the pipe and causing other troubles. When left charged, but out of use, even for an hour, it is best to keep it in a warm spot; and at night, or for longer periods, the liquid contents must be discharged, and the whole interior rinsed out with warm water.

The upper vessel, it will be seen, is a plain cistern with a pipe leading from the bottom, and it needs no further description. The lower vessel has a grated or perforated false bottom, standing on legs made of pieces of lead pipe; also a door or opening by which access can be had from the outside for charging, an emptying hole at bottom closed by a cork (a brass cock would not last long here), and two pipe connections. The space above the false bottom is nearly filled with scrap zinc, which is inserted through the hand hole on the outside, the door of which hole is afterwards made secure. The upper vessel is charged about three-parts full with oil of vitriol (sulphuric acid) and water, in the proportions of one of acid to seven or eight of warm water (always adding the acid slowly to the water), and this immediately makes its way into the lower chamber by the pipe shown.

As soon as this dilute acid reaches the zinc,* a chemical action sets up, giving off a volume of hydrogen gas, which will pass up through the pipe P into the small vessel B (called a wash-bottle), and thence out to the jet. The wash-bottle vessel is kept half-full of clean water, so that the gas, as generated, has to pass through water and become relieved of certain impurities it would otherwise have. There are, however, a large number of home-made machines in use, in which the washing vessel does not figure at all; while many that have it are not kept charged with water.

The passage of gas from the lower chamber to the jet, as just explained, occurs when the cock is open and the gas required for use. When the cock is closed, the generated gas collects in the upper part of its vessel and gathers force until it gradually drives the acid liquid up the pipe, which delivered it, back into the upper vessel. This is claimed as an advantage for the machine illustrated, for when not in use for a short period the acid liquid is driven out of the generating chamber, and active generation of gas then ceases, until the gas-cock is opened again. Let it be noted, however, that too much reliance must not be placed on this, for it is found that after the liquid comes back into the upper vessel gas follows it with some force, which is not only wasteful but decidedly dangerous to anyone near enough to be splashed or have the acid thrown upon him. It is never safe to stand close to or over a machine with open top. Some recommend a heavy lead perforated cap being placed over the opening of the pipe in the upper chamber, and it is well to provide this.

When the machine ceases to generate gas it may need acid and water, or the zinc may have been dissolved. It is more usual though to find carelessness the cause of failure,

* The gas-cock requires to be opened for a moment when charging, that the air in the chamber may escape. If this is not done the acid cannot enter.

and this generally takes the form of allowing the machine and its contents to become cold so that pipe and parts are choked with crystallised sulphate. The chemical process in the machine is accompanied by heat, and this should be retained by a warm casing of wood, or wood and felt. Another cause of failure is the liability of the zinc becoming coated with sulphate, if the machine is carelessly tended. It is not necessary to remove the zinc when the machine is out of use, but after the acid liquor is emptied out the zinc in its chamber should be well rinsed with warm water. Warm water is also the remedy when the zinc becomes coated, but in some cases it takes an hour or two, with three or four changes of water, to dissolve the crystals and get the machine in working order again.

The acid that is purchased varies in strength, and the proportion of water may vary as much as from 4 to 1 to 8 to 1. This, however, is quickly discovered by practice, as is the moment for recharging also. The size of the machine may be about 9 in. wide by 2 ft. 9 in. high. The upper vessel should take, say 2 gal. of liquid. It is far from economical in materials or trouble to have the machine small.

The bellows, for the air supply, are recommended by some plumbers, while others consider them troublesome. With a bellows there has of necessity to be a mate or lad to work them, and if he is unskilled or careless, it is quite impossible for the burner to do his work well; there is also some risk, as will be explained directly. What generally has the most favour is an air vessel, as Fig 35. This is a miniature of the gas-holder of a gas-works, but in this case it contains air only. It is a cylinder working within a double cylinder, the latter having water between its two walls. The inner wall or cylinder can be dispensed with, so that water fills across the whole lower space, if desired, but this means a large bulk of water, which may have to be fetched from a distance, and it makes the vessel very heavy to move, if only for a few feet. The vessel would also need to be stronger to admit of being moved at all when full of water.

The chief detail of the vessel is the valve at top. This can be made of

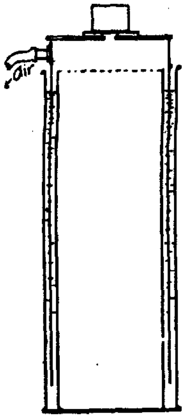

FIG. 35.

any form, a simple door will do, and if necessary a piece of thin sheet rubber will make it air-tight. If a door, then a weight or load must be placed over it to keep it closed. This lower cylinder might be 3 ft. high by 1 ft. 4 in. external diameter, with 1¼-in. or 2-in. water way. The upper working cylinder would be 3 ft. 4 in. high by 1 ft. 2 in. diameter, and for these sizes a load of about 40 to 50 lb. on top will give a nice stream of air.

The burner consists of a breeches-piece, with cocks, as Fig. 36, one leg taking the tube from the hydrogen generator (the machine), and the other taking the tube from the air vessel. From the breeches-piece a single tube proceeds and delivers the mixed hydrogen and air at the jet. The jets can be had of various sizes for different works, but it is necessary that the

nipples be kept free from injury, as too much importance cannot be attached to the sharpness and form of the flame.

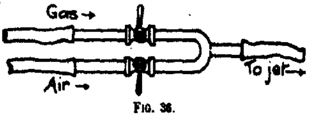

FIG. 36.

Fig. 37 illustrates a working flame. The hydrogen flame is much longer and wavy before the air is turned on.

FIG. 37.

Figs. 38 and 39 also show the flame at work, one on an upright lap seam, the other on a flat lap. With a butt seam, a piece of lead can be used as a

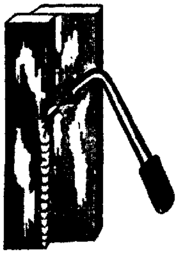

FIG. 38.

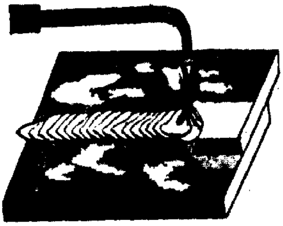

FIG 39.

stick of solder would be; or, what is often done, a strip of lead is laid over the seam and burned at both edges as if it was a seam with two laps. All surfaces which have to come together or be acted upon must be newly scraped bright and clean, and it is equally important that they be quite dry both at the joint and near it. When working outdoors or in draughty places it will be found necessary to shield the flame by a tube over the nozzle, or other means best suited for the conditions.

There now remains something to be said as to the care needed in using the machine. It is necessary to point out that hydrogen, though incombustible by itself, is highly explosive when air is mixed with it. The gas we burn at our gas taps is hydrogen (carrying carbon particles), and while it is confined to the gas holder, or the service pipes, it is harmless. When, however, it issues from gas-burners it mixes with air (the oxygen of the air), and combustion takes place freely. If it issues from the burner long enough without light being applied to it, we get a mixture of hydrogen and air which is no longer harmless but will explode with great force when a light comes near. It would be the same if by any means air was forced into the gas holders so, that they and the service pipes were charged with mixed hydrogen and air (in suitable proportions); for immediately any one applied a light to a burner there would be a disaster, the mixture being combustible and instantly burning back along the services and mains to the gas holders, where the climax would occur.

The burning apparatus consists of a gas-holder and a chamber full of air

which are connected together by rubber tubes.* Both have their gaseous contents under pressure, and when the cocks of the breeches-piece are opened the fact of their both exerting an outward force will prevent their mixing except in the single tube and burner where they are intended to mix. It is when the pressures in the machine and the air supply differ to some extent that one or the other may get a mixture. If bellows are used a novice or careless blower can do it, or a bellows with defective valve can introduce the fault. The machine, it must also be noted, does not generate gas at the same pressure from first to last, but as the charge of acid completes its work, the pressure will decrease. This, however, must be noticed by the operator. The operator must be careful (it is an index to his carefulness) to shut off the gas-cock at the machine whenever he stops burning, even if only for a moment. This care is perhaps not so necessary when an air vessel is used, as this does not cease blowing, but it is when an assistant is working a bellows. It should, however, always be done, and if the machine with the cock on it is out of reach, it is a good plan to introduce another cock just below the gas-cock on the breeches-piece. The two regulating cocks on the breeches-piece are seldom closed, for once the plumber gets these nicely regulated to give a good flame he does not touch them again, unless further regulation is needed. It is only ordinary care that is needed in working a lead-burning apparatus; there are no special risks or trouble. It may be added in concluding this paragraph of precautions, that the likelihood of air getting into the gas-generating chamber and making an explosive mixture there is greatly reduced, if not quite obviated, by the proper use of the wash-bottle B, in Fig. 34, for if this is charged with water as shown, no air could well pass from the gas-tube to the gas-generating chamber, nor could a flame flash by this obstacle. This wash-bottle is much neglected and often empty. In America it is often called a fire-trap. If water is in this vessel the risk of getting an explosive mixture anywhere but at the burner must lie with the air-vessel. If this is a bellows the risk is a real one, but if it is a weighted holder, as Fig. 35, no gas can get into it, owing to the steady powerful stream of air that is passing from it when the cock in the air pipe is open. In concluding this detail of the subject, if an explosion should occur and vitriol is splashed on to the flesh, a solution of bicarbonate of soda should be immediately applied, or washing-soda may be used, if the bicarbonate is not available. There is, however, no more risk with this apparatus than with hundreds of other machines used by mechanics, if ordinary care is used.

As already stated, it is important to see that all air is out of the tubes before attempting to light the gas, otherwise the flame may go back and explode in the tubes or the wash bottle. To be sure of this the beginner can test the gas, and a handy test tube can be made by capping one end of a piece of ½-in. pipe, which should be about 6 in. long. To test the gas, first open the gas-cock on the generator, then open the gas-cock on the mixing fork and let the gas displace the air in the tubes, which it will do in about one minute. Now hold the test tube upright with the open end over the blow-pipe tip for a moment until the gas has displaced the air in the tube. Then quickly place your thumb over the opening of the test tube, which will keep the gas from escaping. Now shut the gas-cock on the mixing fork, and take the test tube to one side away from the generator, still keeping it inverted and closed, and bring it close to a lighted match or candle. It will light with a pop, and if it is free from air it will burn quietly down in the tube until the gas is exhausted.

* The gas from the machine, if it escaped into a small room, would also be a source of danger if it escaped long enough to make an explosive mixture.

Continue to test the gas in this manner until it burns as described, when it may be safely lit at the jet without fear of its burning back. This precaution is necessary only after opening and emptying the generator.

It will be found that the generator evolves gas at a pressure greater than can be used on most work, and for this reason the flame will at first be long, noisy and unsteady, but, as there are two cocks, the volume and pressure can be regulated to the requirements of the work at hand. To note the peculiarities of the flame, close the gas-cock on the mixing fork, until the flame is about 3 in. long. It will be of a pale reddish colour, and will burn steadily, the inner flame not being as yet very well defined. Then open the air cock slowly, and when sufficient air has been admitted the flame will be seen to shoot out suddenly, and then shorten to about $1\frac{1}{2}$ or 2 in. in length. It will be smooth, compact, and keen. If the correct quantity of air has been admitted the inner flame will be plainly seen, and its point where the greatest heat is will be blue. This inner flame is known as the non-oxidising flame, and is the flame which does the work. The temperature of the outer flame is low, and its effect on the lead is to coat the metal with an oxide, and the lead though it runs does not unite. To demonstrate this, bring the point of the inner or non-oxidising flame to bear on a piece of sheet lead. It will fuse bright and clean, and will have a circle of grey oxide around it. Then quickly remove the flame, and the spot will remain bright. Now bring the flame to bear on the same piece of lead at another spot, but keep the point of the inner flame at least $\frac{1}{4}$ in. away from the lead. The lead will melt and flow together, but will be covered with a coat of oxide, and the union will not be perfect. Slowly withdraw the flame, and before the flame is entirely removed the spot will be heavily coated with a thick blue oxide, under which the lead will not unite.

When about to use the gas, open wide the gas-cock on the generator, and do any regulating of the flame with the gas-cock on the mixing fork. These cocks can have pieces of heavy wire brazed or soldered lengthwise of the handles, so as to form lever handles. This will allow the gas and air cocks to be closed or opened by gently tapping the levers, which is the best way to secure a slight variation. To regulate them with the finger means constantly opening or closing them too much, and the result is that, in adding air, too much may be admitted, which will blow out the flame, making it necessary to turn off the air and light the jet again, and this operation may have to be repeated once or twice before the correct flame is obtained.

Always turn on and light the gas before admitting any air, and when ceasing work, the air must be turned off first. If this operation is reversed, an explosive mixture of gas and air may form in the tube with injury to the tube, if nothing else.

When learning this work it should be made a point to study the flame until the colour and form of the proper flame is understood. One of the greatest troubles that the beginner will have is the inability to regulate the flame to the requirements of the work. For instance, a flame that will work nicely on 12-lb. lead will burn holes in 4-lb. sheet before the inner flame gets to work properly. For this reason three different sizes of tips should be used. On 4-lb. sheet, the smallest tip should be used, and the flame before reducing should not be longer than 1 in., and when reduced the inner flame will only be just perceivable, but you can easily tell when it touches the lead by the metal fusing bright. If it is desired to fuse 12-lb. sheet, the $\frac{1}{16}$ in. tip should be substituted, and it will be found necessary to have the jet of gas about 3 in. long, which, when reduced, will be about 2 in long, and show the inner flame quite plainly.

Experiment (or experience) is neces-

sary to determine the size of the flame. The flame should be reduced to a size that will not melt the lead as soon as it touches it. It should, instead, be such that the lead has to be heated first, and the fusing come gradually. In this way it can be determined just what sized drop is required, and it allows plenty of time to place it just where it is wanted. This is important on upright seams, and very necessary on inverted work. It is not necessary to be so particular on horizontal seams, as on seams in that position the result is assisted by gravity. The lead drop that is melted from the upper lap cannot do otherwise than unite with the under lap. It must be remembered that in starting a seam you have cold lead to fuse, and after the first drop is started the lead in its vicinity will be heated almost to the melting point, and it will be seen that the lead runs at the approach of the flame for the next drop.

One of the most important things to impress on the learner is not to hurry the work. Hurried work means holes burned in the sheets, holes which are difficult to patch. The old saying "more haste less speed," can well be applied to lead burning. Sufficient time must be allowed for one drop to set before attempting to place the next drop. Time spent on practising at the bench is time well spent, as many little details that cannot be brought to the beginner's attention here will be learned in that way.

Seams.—There are only two kinds of seams, viz.: the butt seam and the lap seam. The butt seam is used principally for joining horizontal waste pipes and in lengthening traps, or for any purpose where it is desired not to have the point of junction show. With this form of seam, the lead can be heated until fusion takes place nearly through the sheet. It is generally desirable to add lead to the seam to make it as strong as the sheet it joins, unless the article is of such a size and strength as to allow of its being burned on both sides, which makes the strongest of seams. The sheet for butt seams is prepared by rasping the edges of the lead sheet to be joined straight and true, so that when the edges are brought together they will fit close everywhere. The edges are then shaved for a distance of ⅛ inch each side of the edge, making a seam ¼ inch wide. When jointing heavier than 12 lb. lead the edge should be shaved at an angle to form a deep V-shaped groove, and the seam is then made by adding lead to fill the groove. This allows the fusion to take place nearly through the sheet. The butt seam is the simplest form to burn, no matter in what position it is placed.

The lap seam is most commonly used, and of the two is generally to be preferred. As it is not necessary to cut and trim the edges true, it dispenses with any additions of lead, except in rare instances. It leaves one hand free to handle the shave hook, and the lap can be dressed to fit any uneven spots. It also makes the next best seam to through fusing. By lap seaming, a tank can be lined in about half the time required to butt seam the same article.

The sheet for the lap seam is prepared, as its name indicates, by lapping one sheet ½ in. to ¾ in. over the other sheet. Let the under edges be shaved clean, also the upper edge. The lead required to make the seam is melted from the upper lap and is fused on the lower sheet. There is no reason why the lead at the point of juncture should not be made as thick as the original lead. This is the point to be aimed at in practising the work, and a reliable way of determining the strength of an experimental seam is to cut squarely across a finished seam, then bend the seam slightly. The thickness can then be noted. The beginner should practise the different seams, until the thickness of the joint can be told by the looks of the lead. A few days' practice at the bench will soon train the eye to recognise good work.

The only way to acquire efficiency is

by practice, sufficient practice being necessary to satisfactorily master the blow-pipe and flame, and in practising do not be discouraged, for it is work that has been done before, and can be easily done again.

When the beginner first tries to make a flat butt seam, he should use pieces of sheet lead about a foot long, as strips of that length are much easier to prepare. The edges are made straight with a fine rasp which is held lengthwise and parallel to the edge to be trued. The rasp must be used lightly, or it will be apt to tear the lead, and so leave it in worse condition than before using it. The edge should then be gone over with the shave hook and cleaned. Next shave the top surface a distance of ⅛ in. each way from the edge, which will make a seam ¼ in. wide when finished. The edges are now butted together, and the sheets firmly secured to a board with a few tacks. The extra lead that is necessary to add to make a full joint must be obtained from a strip of lead, which should be about ⅛ in. square and shaved clean.

The burning should be begun at the end of the seam nearest the operator. With the point of the inner flame melt off a drop from the lead strip, and have it fall squarely on the seam just slightly in advance of the point of fusion. Follow it up with the flame, placing the point of the inner flame directly over the edges of the seam, which is almost under the lead drop. As soon as fusion commences on the lead seam, the melted drop will flow to the bright spot and immediately unite with it. The flame must then be quickly removed, and the drop be allowed to set.

The drop will cool immediately upon the flame being removed from contact with it. It is not necessary to wait for any specified time, but if the flame is allowed to play constantly on the sheet it is apt to get overheated and when in that condition it takes very little heat to make the lead run like water. To avoid this the flame should be lifted clear of the seam for an instant after each drop has been formed. Now melt off another drop and let it fall as before, only it should lap on the previous drop about one-half its diameter. Secure it to the seam as before. This operation should be repeated until the seam is completed. This form of flat seam should be well practised, as it makes the beginner familiar with the blow-pipe flame. Practice certainly should not cease, until the flame can be brought to the lead without burning holes through it, this being a thing that will probably happen at the first trials.

It is not usual for the butt seam to be used on upright work if it is at all large, as it is a difficult matter to make an upright butt seam that will stand the test. If a finished seam was cut into short pieces, an examination of the severed ends would show many weak places that appeared to be strong, the reason of this is that the heat necessary to fuse through the lead will cause the lead to run from the seam and leave a gap, or at least, a thin place.

To practise upright butt seams, prepare the work as just described for flat seams, but let the sheets be securely tacked to a board which can be supported in an upright position. The burning is begun at the bottom of the seam. The flame should be shortened considerably, as the fusing is required to take place somewhat slower than with flat seams, for in upright or inverted seams gravity has to be overcome, and the operator must have plenty of time between the commencement of brightening and the actual fusing to drive the melting drop to the required position. The blow-pipe is held so that the flame strikes the seam squarely and at about a right angle with the sheet. When fusion starts the flame should be drawn quickly towards one side, and if the lead is at the proper temperature the melted drop will follow the point of flame, and as it comes in contact with the adjoining edge, it will properly unite. It is not necessary to add lead

to these seams oftener than at intervals of 5 or 6 in., or, as often as the lead shows signs of weakening, when it may be added by holding the lead strip against the lead sheet and slightly above the flame. The melted drop will unite with the sheet and can then be driven to any desired position. This seam will show the characteristic leads, but they will lie nearly level with the lead sheets, and if a scratch cloth be rubbed over it, nearly all traces of the seam will be removed. To make a really strong seam it must be gone over with the flame at least twice, for after fusion of the edges takes place the flame can be used quite strong without fear of the lead running from the seam. Do not cease practising this seam until it is nearly perfect.

The horizontal butt seam is seldom used in a general way, but it has to be occasionally made. To practise this, prepare the sheets and tack them securely to the board, as previously described. The board is then placed in position with the butted edges horizontal. The flame should strike the sheet nearly square. The edge of the upper sheet should be heated first, and as it brightens, the flame should be directed on to the edge of the lower sheet. If properly done, fusion will at once take place. The object sought is to get a light fusion between the two sheets before attempting to burn the lead clear through the seam. If this is not done, the lead will run from the upper sheet and cause holes, or at least will seriously weaken the upper sheet. After fusion is once obtained it is a simple matter to go over the seam a second time, which can then be fused through without much danger of burning holes through the sheet. Lead can be added in the same manner as in upright seams, if required.

The Inverted Butt Seam is used for jointing waste pipes which conduct acid from tanks. These pipes are usually in a horizontal position and the seams must be burned in place. The most difficult part of a seam is in starting it. When fusion has once taken place, the rest of the seam is easy. The seam is prepared the same as described for other butt seams. Care must be taken to have the edges butt close, and the blow-pipe flame must be made as short as possible and still melt the lead. The point of the inner flame is placed squarely on the seam. Both edges must be heated at once. If the edges begin to brighten, and do not show an inclination to fuse, the flame should be drawn quickly to one side, and the melted drop will follow the point of flame and unite with the adjoining edge. This seam, in common with other butt seams, should be gone over the second time to assure a perfect seam. It is difficult work to add lead to the flat inverted seam, but when necessary it should be done by burning the end of the lead strip to the seam. The strip is then melted off, leaving a drop of lead affixed to the seam, which can then be drawn to the required spot with the flame. The finished inverted seam shows pits upon examination of the reverse side of the sheets. These are caused by overheating. The operator will often be surprised at the inverted butt seam showing a remarkable fulness. This is accounted for by what is just stated. The lead upon the application of the heat, runs from the upper or back side of the sheet and forms a very full seam. For that reason the inverted butt seams always appear stronger than they really are.

The Lap Seam is most commonly used for practically all purposes. When the beginner becomes proficient with the blow-pipe, no trouble will be experienced in making lap seams that will show, when cut, a joint equal in thickness to the sheets that are joined.

Lead sheets for flat lap seams are prepared by shaving clean the exposed edges; also the surfaces where the sheets touch each other. The upper edges can then be shaved for a distance of ½ in. each side of the lap. The sheets should be lapped ½ to ¾ in., according to the weight of the metal.

It will be understood that light sheets will not require as large a lap as heavier sheets. The object of lapping is to leave the sheets practically as one piece, to effect which the lead is melted from the upper sheet. It may be roughly allowed that 12 lb. sheet should be given a ½ in. lap, while 20 lb. sheet needs ¾ in.

The flame for lap seams is brought to bear squarely on the edge of the upper sheet with a slight slant in the direction of the under sheet. When the edge has brightened to almost fusing point, the flame should be diverted quickly from there to the lower sheet. If the metal is sufficiently hot, the melted drop will follow the point of the flame, and at once fuse with the lower sheet. This process is repeated, advancing ⅛ in. to ¼ in. each time, according to the thickness of the sheet. The smaller the piece taken at the time the better. Even skilled operators do not attempt large pieces, see Fig. 38.

In making a horizontal lap seam the procedure just described, in preparing the lapped edges, should be followed. The lap is arranged that the edge of the upper sheet shows upwards, and the flame is directed downwards on to this edge, the same as would appear if the right side of Fig. 39 was the top of that illustration. As the drop commences to melt, it will have a tendency to flow downwards, but at that moment the point of the flame should be directed to the back or under sheet, which will brighten at once, and, by directing the flame for another moment on the drop, the two will at once unite.

The inverted lap seam is usually considered as difficult as any, although, with sufficient practice, the operator finds it as easy as the others. Let the flame be as short as possible, and apply it at a slight angle from the upper towards the lower sheet. Good practice is to have an upright piece of work which is bent over at right angles to make part of it an inverted seam. First burn the seam up the upright piece to the angle, complete the angle, then go along the inverted piece. When a man can do this reasonably well, he is ready to undertake any work that may be given to him.

In making burned joints to lengths of pipe, or for lengthening traps, etc., the butt seam is commonly used. First, with a drift plug and a dresser, get the pipe ends quite true in roundness, then rasp and shave the ends that they may butt true together. If it is possible, let a thin piece of cardboard, or stiff thick paper, be rolled to go inside the pipe at the joint, as this will prevent lead getting through, or rough edges being formed. Assuming the pipe to be fixed horizontally, the burning should be started on the under side and then proceed upwards on both sides, finishing at the top. If practice has been had with flat and upright seams, no difficulty will be experienced with the pipe. No lead need be added, unless a hole is made. With a hole on the underside, it will be found necessary to melt a piece of lead at a higher point, then, with the flame, make it flow down to the hole.

In the case of heavy pipe, requiring a joint that will withstand pressure, the "burned-through" butt joint is used. To do this the outer edges of the pipe ends are bevelled, so that when they come together a V-channel is formed into which lead is melted. For good work only about half the thickness of the pipe is bevelled, leaving half—the inner half—flat to form a true butt joint to this extent. This part is then burned together in the ordinary way, after which the channel is filled with added lead burned in.

In making lap seams in pipes, tees, etc., the burning is done exactly the same as lap seams with flat work, but the initial preparation is different. In making a lap joint with pipe the same process is followed, in preparing the ends, as when a copper-bit or a blowpipe solder joint is to be effected. One end of the pipe is opened out with a

tan-pin, or with a drift-plug one size larger than the pipe, while the other end is rasped and shaved to a long bevel edge which will slip into the opened end. Having shaved all parts clean as with a lap joint, the burning is commenced and finished as already explained.

LEATHER.

DYEING, STAINING AND JAPANNING, AND MISCELLANEOUS RECEIPTS.

Chamois Leathers.—Ordinary wash-leather, which will be the most familiar instance to most readers, is made from the inner split of sheepskins, often called "sheep linings." The skin, after being deprived of its wool by the fellmonger, is limed for a short time to plump it tolerably, and in this state is split into two thicknesses by a machine which draws the skin over a steel straight-edge against a straight blade to which a rapidly reciprocating motion is given by an eccentric. The grain split, which, curiously enough, is considerably the larger of the two, is used for the manufacture of the thin fancy leathers so often used for bookbinding and portfolio work, while the lining goes for wash-leather. It is first freed from lime by bran drenching, and the loose and fatty layer which exists in the centre of a sheep-skin is removed with a sharp knife on the beam. The skins are then placed in the "stocks" or fulling-mill, which is used for the softening of dried hides, and pounded till a part of the moisture is evaporated, and the fibrous structure has become somewhat loose and open, sawdust being generally added to facilitate the process. Oil is now added in small quantities, cod-liver oil of a crude sort being generally used in this country, though on the Continent, whale oil and other marine oils are frequently substituted. The oil is gradually absorbed by the skins, replacing the water, which evaporates, the skins being occasionally hung up for a short time exposed to the air to facilitate the operation. When the water has been entirely expelled, the skins lose their original limy odour, and acquire a peculiar mustard-like smell due to the oxidation of the oil.

They are now somewhat loosely packed in a box, where they heat rapidly from continued oxidation of the oil, and must be taken out and exposed to the air at intervals to prevent overheating and consequent injury, since the oxidation of drying oils takes place so rapidly as in many cases to produce spontaneous combustion. During this heating process, much pungent vapour of acrolein is given off, the colour of the skins changes to a pronounced yellow, and the tanning process is complete; but it still remains to rid them of the superfluous oil. In the old English process this is accomplished by washing with warm soda solution, by which the oil is partly saponified and partly emulsified so that it can be washed out. In France, where the oxidation takes place more gradually, the skins being freely exposed to the air by hanging frequently during the stocking process, and the final oxidation being also accomplished by hanging in warm rooms, the oil is much less viscid, and a large portion of it can be removed by dipping the skins in hot water, and then wringing or hydraulic pressing. The oil pressed out in this way constitutes the pure *moellon dégras*, or *première torse*, which, after mixing with tallow and other cheaper fats, constitutes the degras of commerce so much esteemed in currying. The oil obtained in the English way by washing out with soda, and afterwards acidifying the solution, is known as sod oil, and is much less esteemed, but as some English chamoisers now work in a way very little different from the French, and obtain their oil by pressing, it is hard to see why it should not be equal to the French product, if properly used. White wash-leathers are made by bleaching in the sun, the skins being moistened with water and the alkaline fat-liquor obtained in washing out the remaining oil; or the bleaching is accomplished by oxidising agents, such as permanganate, followed by treatment with sulphurous acid to remove the manganese peroxide formed; or by sodium peroxide. Oil leathers are the only ones except chrome leather which will stand the action of hot water, and indeed immersion in hot water is constantly used on buff leather to shrink or "tuck" the leather so as to make it thicker and more compact.

Staining and Dyeing Leather. There is a difference in staining and dyeing as will be noticed in the following. Aniline dyes are now mostly used for the latter, but until their use was properly understood, they gave very uncertain results. Much depended on the tanning, as, for instance, a dye and formula that gave good results with morocco were found to give quite different results with Russia leather.

Staining.—This is most applicable with dye-liquors prepared with decoctions of the dye-woods, a sufficient depth of colour being obtained by repeated applications of the liquor, while dyeing, which usually means the dipping of the leather in dye-liquor, is more applicable for aniline colours, because a more even colouring is obtained. If aniline colours be laid on with a brush, it is seldom easy to get a uniform colouring or shade, as these dyes have a great affinity for organic substances, like leather, and immediately an aniline dye touches the substance it colours it at once, so that a single brushful of liquor will give an uneven effect, deepest where the full brush first touches and lighter where the nearly exhausted brush leaves the surface. If these dyes must be used as stains, that is, applied with a brush, then the work must be quickly done with fully charged brushfuls of liquor, so as to quickly get sufficient to float the skin all over before any part has absorbed too large a proportion of the dye.

The following process would be adopted to stain a goat or deer skin, tanned for morocco leather.

It is a good plan, after cleansing the dye table, to brush the table over with a decoction made by boiling crushed

linseed in water (and straining it), this liquor being equivalent to a coat of mucilage. It causes the skin to cling to the table, which prevents its slipping, and afterwards admits of the table being cleaned of all dye stains by simple washing with hot water.

To prepare for staining, have all the liquors ready in bowls, one for the dye liquor, one for the mordanting fluid, another the "striker," and a fourth of cold water. It is better to have a rubber tube from a tap for the cold water, as running water is desirable for removing superfluous dye liquor from the stained skin.

Lay the skin flesh-side down on the table with the head towards the left hand, and moisten it with a sponge dipped in clean tepid water. To ensure the moisture being evenly distributed, go over the skin with a glass "slicker" to press out all superfluous water. When this is done, the mordant is applied. A mordant does not always have a chemical effect on the colour, it often being used to ensure that the dye liquor strikes more readily and evenly, and so ensures a uniform shade. With morocco leather, there are some dyes that do not require a mordant at all.

Apply the mordant with a large hair brush and lay it on all round the edges first, then zigzag across the middle. After mordanting half a dozen skins and laying aside over a trestle to allow the mordant to penetrate, take the skin first done and, after wiping the table clean, lay it on as before. Next apply the dye liquor in just the same way as the mordant was laid on. One coat of dye liquor is given each mordanted skin, commencing with No. 1, then a second coat, and a third and fourth as required.

A "striker" is a fluid which is applied to a dyed (or stained) skin to modify the colour or tint (sometimes it is a mordanting fluid) and it is applied after the staining.

When the work of colouring is thus completed, all superfluous dye is washed off with water. Water is poured on and the dyed surface brushed, or, it is better to let water run on the skin from a tap or hose. When this is done, the remaining water is "slicked" off, unless the formula states otherwise, and finally the skin is hung in the drying loft. The sun must not be allowed to shine on the skin whilst drying.

The dried stained skins next go to the finisher, who gives a gloss to the coloured surface. For morocco skins that have been stained with dye-wood liquors it is prepared as follows: Take 21 oz. curd soap, 2½ oz. pure hog's lard, and 3¼ oz. crystallised carbonate of soda, and boil them in as much water as will dissolve all; then mix in 21 fl. oz. of decoction of flax seed. This quantity will finish a gross of skins. The liquid is laid on lightly with a sponge, allowed to dry on, and then dry rubbed lightly with a piece of flannel. The skins are then ready for the market. Should the finished skins be somewhat stiff, they can be softened by laying them in damp pine sawdust. Let two skins be laid grain or coloured sides together, so that only the flesh side touches the sawdust, then cork-board them.

Dyeing Morocco Leather with Aniline Colours.—This is an easier process than staining, and, in the hands of a practised dyer, the very finest results are obtained. Owing to the rapidity with which aniline dyes colour leather, it is best to work with two or three baths of various strengths. One chief reason for this is that if one bath of full strength is used for the first bath, the resultant colour will have a bronze hue, which is not removable and which, in most cases, is considered to quite spoil the effect. By using two or three solutions, commencing with a weak one and ending with one of full strength, a more uniform colour is obtained, with greater brilliancy.

For general use with morocco leather that is to be dyed with aniline colours, the mordant is tannic acid (8 oz. acid

to 1 gal. of water). Or a mordant of sumach liquor of the same strength may be used. For alkaline dyes sulphate or phosphate of soda, 1 part to 100 of water, is used.

In dyeing (that is dipping) morocco skins, it is the rule to put two skins together, flesh side to flesh side, and sew the edges. They are treated in this way with the result that only one side of each side is dyed, which is all that is necessary, and a considerable saving in the dye liquor is effected, as the flesh sides, if exposed, would absorb a deal of liquor. A certain amount works in between the sewed edges a few inches, and dyed skins can generally be recognised by this.

The process is as follows: Apply the mordant to each skin; the pair is thrown over a pole, and the mordanting of about six more pairs follows. Then take the first pair and examine them to see if the mordanting is properly done. Too much of the liquor must not be left, and if, on pressing the grain side with the thumbnail, liquor exudes, the skin should be lightly slicked to remove excess mordanting liquid. If, on pressing the thumbnail as explained, the part pressed shows up lighter than the other part, then the skin is sufficiently mordanted.

After the mordanting is properly done, take a pair of skins and dip these in the weakest solution of dye liquor, and work about until uniformly coloured. Then lift them out, and put them in the second or medium strength bath, and after working a few minutes pass them into the third and full strength bath. Work them about in this until the desired colour is obtained. A little practice is needed to decide the colour, as the tint is darker while wet than when the skin has dried, therefore a deeper tint must be allowed to the skin, when it comes from the last bath.

When the colour required is obtained, no time should be lost in swilling the skins in or under plenty of water to remove superfluous dye. If left in the last bath too long, the troublesome bronze hue will be obtained, and the same applies, if the skins, when taken from the bath, are not washed quickly. After washing put the skins to dry.

In dealing with the second pair of skins these should be first put into the second bath, then into the third bath, finally into a newly prepared bath of the full strength. This is necessary for uniform colouring, and is the most economical method. The dye baths should be used at about 80° to 90° F., all through the dyeing, and it is a good plan to put a small piece of leather through all the processes before commencing with the skins.

In finishing these skins they may be first softened with damp pine-wood sawdust as already mentioned, then boarded with a cork arm-board and finally given a coat of finishing gloss, as described under staining. A different material, however, is used for the gloss, usually some secret of the operator, but a good finish for aniline dyed morocco skins is prepared as follows:—

Put some new milk in a stoneware jar, and place this on a hot plate or before a fire that the heat may curdle the milk. This will take several hours. Strain off the curds and wash these in hot water until the water shows no sign of milk and is neither acid nor alkaline. When this is done—and it must be done thoroughly—dissolve the curds in liquid ammonia and stir until the whole is like cream. This is the desired finish and it is applied to the dyed leather with a sponge and when dry the leather is ready for the market. If at all stiff after drying, soften by hand slicking, this does not efface the grain like a machine.

Patent, Japanned, or Enamelled Leather.—These are terms used to designate those leathers, whether of the ox, the horse, the calf, or the seal, which are finished with a waterproof and bright varnished surface, similar to the lacquered wood-

work of the Japanese. The term "enamelled" is generally used, when the leathers are finished with a roughened or grained surface, and "patent" or "japanned" are the terms used, when the finish is smooth. Though generally black, yet a small quantity of this leather is made in a variety of colours.

(1) For boots, shoes and light goods, seal-skin (the skin of the common hair-seal) is used; while for harness and similar work bullock hides of any heaviness may be used.

The tanning process is that commonly known as "union," being a mixture of oak and hemlock barks. Previous to tanning the soaking, unhairing, liming, etc., are done in the usual way. When the tanning is about one-third done, with heavy hides, a buffing is taken off and is then split into three layers. The top or grain side is reserved for enamelling in fancy colours and for special uses. The middle is largely used for carriage trimmings and parts of harness, the flesh side for shoes and similar purposes. The tanning is then completed by subjecting the liquor to a gambier liquor instead of the bark liquor.

When the splits are fully tanned, they are laid on a table and scored, then stretched in frames and dried. After drying each one is covered on one side with a compound as follows, this being to close the pores of the leather and make a surface suitable for the varnish.

Take 14 lb. of raw linseed-oil, and add to it 1 lb. dry white-lead and 1 lb. silver litharge. Well mix, then set to boil, stirring constantly until the mixture is thick. A little should be spread on a sheet of iron or china, and if it dries into a tough elastic substance like rubber, in 15 or 20 minutes, it is ready. This compound is put on one side of the leather while it is in the frame. For a second quality enamelled leather (not the best patent), chalk or yellow ochre is added to the above mixture while it is boiling, or while fluid before using it. When thus treated the frames are put into a rack in a drying closet and dried at a temperature starting at 80°F. and rising to 160° gradually. The air should receive its heat from steam pipes, not from a stove.

After drying, the ground coat just referred to is pumiced to smooth the surface, and is then given two or three coats of enamelling varnish which consists of prussian blue and lampblack, boiled with linseed-oil and (after removal from the fire) thinned with turpentine. The thinning makes it suitable for flowing evenly over the surface of the coated leather. It is applied with a brush and each coat is dried, then pumiced and rubbed with tripoli powder, before applying the next. The last coat is, of course, left untouched. The leather is now ready for market.

Another recipe for the varnish is 2 oz. vegetable black, 9 oz. prussian blue, 90 fluid oz. of raw linseed-oil. These are boiled together as already explained, and then thinned with turpentine.

Enamel varnishes should be made and kept several weeks, in the same room as the varnishing is done, so as to be always in the same temperature.

(2) Leather destined to be finished in this way requires to be curried without the use of much dubbing, and to be well softened. The English practice is to nail the skins, thus prepared and quite dry, on large smooth boards, fitted to slide in and out of stoves maintained at a temperature of 160° to 170° F. (71° to 77° C.), coating them repeatedly with a sort of paint composed (for black) of linseed-oil, lampblack, and prussian blue, well ground together. Each coating is allowed to dry in the stoves before the next is applied. The number of coatings varies with the kind of skin under treatment, and the purpose for which it is intended. The surface of every coat must be rubbed smooth with pumice; finally, a finishing coat of oil varnish is applied, and, like the preceding coats, is dried in the stove. The exact degrees of dryness and

flexibility, the composition of the paint, and the thickness and number of the coats, are nice points, difficult to describe in writing. This branch of the leather industry, so far as it relates to calf-skins, is carried on to a larger extent, and has been brought to greater perfection, in Germany and France than in England. In the former countries, the heat of the sun is employed to dry some of the coatings. The United States have also brought this style to a high degree of excellence, especially in ox-hides. There, use is made of the oils and spirits obtained from petroleum, and without doubt French and German emigrant workmen have materially assisted in attaining this high standard. Leather finished in these styles is used for slippers, parts of shoes, harness, ladies' waist-belts, hand-bags, etc., and has now maintained a place amongst the varieties of leather for a long period of years. (Spons' 'Ency'.)

(3) The first coats of the japan for patent leather are made with linseed-oil and prussian blue, boiled together for some hours; the last coat of varnish with linseed-oil and lampblack, similarly boiled. Each coat is separately dried at a temperature of 160° to 180° F. (72° to 82° C.), and rubbed on the leather by the hand, the skin being nailed on to the surface of a board. The process is a very delicate one, and requires special knowledge in each part of the operation.

(4) *To Separate Sides of Patent Leather.*—Patent and enamelled leather will, if the glazed sides are placed together in warm weather, become stuck together, and unless carefully separated, the leather will be spoiled. The simplest and best way to separate sides is to place them in a drying or other hot room; when hot, they can be taken apart without injury to the glazed or enamelled surface. If a drying-room is not accessible, lay the sides on a tin roof on a hot day, and they will soon become heated sufficiently to allow their being separated without injury. *Any attempt to separate without heating to a high degree will prove a failure.*

(5) When the enamel of the leather has chipped off, clean the parts well with fuller's earth and water, and then apply varnish. In the first manufacture, the primary coat is made of pale prussian blue and the best drying-oil, boiled together. When cold, a little vegetable black is ground up with it, and after application to the leather, it is stoved at a gentle heat, and polished with a piece of fine pumice; a second coat, which consists of the same varnish with some pure prussian blue mixed with it, is then applied. There are also third and fourth coats applied, the last being made of 2 oz. pure prussian blue, 1 oz. vegetable black, 1 qt. drying-oil, with a little copal or amber varnish. Each coat is stoved, and rubbed with pumice. For the purpose of repairing, use all "last coat," stoving at a heat not exceeding 160° F. (71° C.); but take care that the pigments are carefully ground in the drying-oil, and don't add the amber varnish till the third and last coat.

Russia Leather.—(1) The odour given to this leather by the Russian curriers was long kept a secret, but it is now known, and "Russia" leather is now made in many countries.

The skins used are goat, large sheep, calf, cow and steer hides, and the preliminary operations of soaking, unhairing and fleshing are done in the usual way. The skins are then put to swell in a mixture of rye-flour, oat-flour, yeast and salt. This mixture is made into a paste with water, and then thinned with more water, sufficient to steep the skins in. For 100 skins take 22 lb. rye-flour, 10 lb. oat-flour, a little salt and just sufficient yeast to set up fermentation. The steeping of the skins in this mixture takes two days—until they are swelled up, after which they are put in a solution of willow and poplar barks, in which they remain eight days, being frequently turned about. The tanning is afterwards completed by putting the hides into a tanning liquor composed of

willow and pine barks, equal parts. They remain eight days in this liquor, then a fresh liquor of the same kind and strength is made up, and after the hides are hardened and split, they are again steeped in this for a further eight days. This completes the tanning.

The next process is to cut the hides down the middle, from head to tail, into sides. These are scoured, rinsed and dried by dripping, and then passed to the currier. He slightly dampens the dry sides and puts them in heaps or folds them together for a couple of days to temper. They are then impregnated with a mixture of two-thirds birch oil, and one-third seal oil. This is applied on the flesh side only for light leather, and on both sides for heavy leather. The leather is then "set out," "whitened" and well-boarded and dried before dyeing.

For Russia-red colour, a decoction of sandal-wood alone, or mixed with cochineal, is used. This dye liquor is applied several times, each coat being allowed to dry before the next is applied. A brush is used for this, and the dye is put on the grain side only. In Russia, the mordant used, before applying the dye, is a solution of chloride of tin.

To prepare the dye take 17 oz. of sandal-wood, and boil this for one hour in 6 quarts of water; then filter, and dissolve in the filtered fluid 1 oz. of prepared tartar and soda. Boil the whole for one hour, and set aside a few days before using.

When the dyeing is completed the leather is again treated with the mixture of birch and seal oils, applied to grain side with a piece of flannel and when the dyed leather is dry a thin smear of gum-dragon mucilage is given to the dyed side to save the colour from fading. The flesh side is smeared with bark tan juice and the leather is then grained for market.

(2) This is tanned in Russia with the bark of various species of willow, poplar, and larch, either by laying away in pits or handling in liquors, much like other light leathers, the lime being first removed by bating, either in a drench of rye- and oat-meals and salt, by dog dung, or by sour liquors. After tanning, the hides are again softened and cleansed by a weak drench of rye- and oat-meals. They are then shaved down, carefully sleeked and scoured out, and dried. The peculiar odour is given by saturating them with birch-bark oil, which is rubbed into the flesh side with cloths. This oil is produced by dry distillation of the bark and twigs of the birch. The red colour is given by dyeing with Brazil-wood; and the diamond-shaped marking by rolling with grooved rollers.

Much of the leather now sold as "Russia" is produced in Germany, France, and England. It is tanned in the customary way, occasionally with willow, but more generally with oak-bark, and probably other materials. Economy would suggest the use of such materials, as from their red colour, are objectionable for other purposes, and therefore cheap. The currying is in the usual manner, care being taken that the oil used does not strike through to the grain, which would prevent it taking the dye. The colour is given by grounding with a solution of chloride of tin (100 parts perchloride tin, 30 parts nitric acid, 25 parts hydrochloric acid, allowed to stand some days, and the clear solution poured off, and mixed with 12 volumes of water). The dye-liquor may be composed of 70 parts rasped Brazil-wood, 3 parts tartar, and 420 water, boiled together, strained, and allowed to settle clear. The grounding and dyeing is done on a table with a brush or sponge. The odour is communicated by rubbing the flesh-side with a mixture of fish-oil and birch-bark oil, which sometimes contains no more than 5 per cent. of the latter.

Brown Leather for Boot Uppers. — The greatly extended demand for brown boots has made the particulars of staining the leather much sought after. *The following*

recipe gives good results. The process is to first mordant the leather with bichromate of potash, then, before this is quite dry, the dye-liquor is applied. If the colour dries out too red a tint, a single application of the mordanting fluid will reduce it.

To prepare the mordant, put some crystals of bichromate of potash into a pint of cold water. Let this remain one hour, but shake it frequently. Then pour off the liquid from the undissolved crystals and dilute this liquid with warm water until it is of a pale straw colour.

For the dye-liquor, dissolve Bismarck brown in boiling hot water, 1 oz. to the gal.; allow this to digest one hour, then strain off the clear liquid from the tarry matter. This requires no further dilution, and is applied with a brush, as described under "staining."

By varying the bichromate of potash solution, various shades of brown are obtained, but it should not be used too freely or the leather will become harsh and liable to crack on the grain side when boarding. When stained, dry the leather in the shade, and afterwards soften it by the use of damp sawdust and boarding, as explained. For a chocolate brown, stain as described, then tone with a weak solution of green copperas in water (½ to 1 oz. to a gal.).

Blacking Brown Leather Boots.—All applications of brown polish that the boots may have had must be first removed, this being effected with a strong solution of washing soda, used hot. Rub until the leather is cleaned of all old polish. Make a weak solution of green copperas (it must not be strong), and apply one or more coats with a brush until the desired blackness is obtained. When this is done, take some tallow (a tallow candle), and rub it into the leather, rubbing well until it is warm with the friction. The boots are then ready for the application of the ordinary blacking or boot polish.

Adhesive for Leather.—Take equal parts of ordinary glue and isinglass, put them in a saucepan, cover with cold water and let stand (cold) for a night, say 10 hours. Then boil up, and after seeing that the materials are perfectly melted, add pure tannin (tannic acid) until the mixture becomes ropy, having a consistence like white of egg. For using on leather, first get the two surfaces quite even, then buff them, and apply the cement warm to both surfaces. Rub the cemented surfaces together, then press tightly and allow a few hours to dry. This cement is considered capable of joining machine-belting without riveting.

LEATHER CLOTH OR "AMERICAN" CLOTH.

(*See also* WATERPROOFING.)

(*a*) As a substitute for leather, enamelled cloth is now largely used where lightness and pliability are desirable. Having the appearance of leather, and nearly, if not quite, its durability, it is used where strength is not so important as a good appearance. In the covering of carriage tops, the upholstering of furniture, the covering of trunks and travelling bags, a great quantity is used, and it is also employed in garments, coverings, etc., as a protection from water. The details of its manufacture are very simple.

The foundation of the article is cotton cloth of the best quality, and generally made expressly for this purpose. The cloth is taken from a bale and wound upon a large cylinder preparatory to receiving its first coat. It is then passed between heavy iron rollers, from the top one of which it receives its first coating of composition. In many places the covering is spread by a knife under which the web passes. The composition is made of linseed-oil, lampblack, rosin, and a few other ingredients, which are boiled together till they reach the consistency of melted tar. From between the cylinders it is carried to a drying frame made in the shape of a reel, and subjected to a high temperature in the drying-room, which is heated generally by steam-pipes. After the drying process it is given to workmen, who make all the rough places smooth by rubbing with lump pumice and water. The cloth is then passed through the same operations as before, rolling, drying, and rubbing, and this is repeated 3 to 5 times, or until the required thickness has been laid on. After the last scrubbing down, the fabric is taken to another department, thoroughly varnished, and again passed through the heater. It now appears as a piece of cotton cloth, with one black side looking very much like patent leather. One step yet remains to be taken. The cloth is passed between heavy rollers, which cover its surface with regular indentations resembling the grain of leather. It is now ready for the market. As many frauds are perpetrated in this article as in any other, manufacturers who desire to turn out a heavy material, first fill the cloth with clay, and the result is an enamel that will crack during the cold weather of winter; or, in their endeavour to produce a cloth that will stand a low temperature without cracking, they make material that will be sticky in summer. The poor quality is used in the cheap trunk and bag trade, but none but the best will do for the outside wear that comes upon carriage tops. ('Manufacturers' Gazette.')

(*b*) Dr. Ballard has some valuable remarks on this manufacture in one of his reports. The japan or enamel used for enamelling cloth or leather is usually prepared, he says, by boiling prussian blue or peroxide of iron in raw linseed-oil. At the Leather Cloth Co.'s works at Stratford, the pots for making it, 16 in number, each holding 150 gal., are set in brickwork and arranged along 2 sides of a building devoted to the purpose. The pots are enclosed in brickwork chambers having sliding iron shutters in front, which can be drawn down during the boiling. The fumes escape by pipes, and are drawn away by a fan, and delivered into the ashpit of the boiler of the works, for consumption, thus preventing nuisance. The pots are fired from the rear, and the enamel is allowed to cool before being ladled out.

The manufacture of leather cloth (American cloth) and of table covers is carried on at some places on a very large scale in extensive factories, and at others in much smaller establishments. The details of the operation may differ in different works, correspondingly with differences in the precise article manufactured and the use

to which it is to be applied; but the essential features of the business are the same in all works. The enamelling of leather and pasteboard for the preparation of what is called "patent leather" and the peaks of military and other caps is a very similar process, but is conducted only in small establishments.

The enamel used at the smaller establishments is ordinarily purchased from persons who prepare it; but at the larger establishments it is usually made on the premises. Briefly, the process consists in laying on the varnish or enamel smoothly upon the cloth, etc., and then exposing the varnished material to a high temperature in an oven or heated chamber.

For the making of table-covers, the cloth is usually manipulated in convenient lengths, and the same is mostly the case when leather cloth is made in the smaller establishments for the covering of boxes and cabs. In the large establishments for the manufacture of leather-cloth, the cloth is made in rolls of many yards in length. In some cases, the cloth undergoes preparation before the varnish is laid on, with the object of preventing imbibition, and sometimes to impart thickness and substance to the article made. This preparation consists either in sizing the surface, and perhaps after sizing putting on a layer of paint, or in laying on at once a paste made with boiled linseed-oil, whiting, and water. When the surface thus prepared is dry, the varnish is laid on. When a long roll of cloth has to be varnished, the varnish is spread on by means of a machine adapted to the purpose, which puts it on smoothly and evenly as the cloth passes through it, and as the cloth leaves the machine it goes on directly to the drying chamber. When the cloth is varnished in lengths, it is laid upon a long smooth table, and a workman lays the varnish on evenly by hand, using for the purpose a flat instrument or scraper. After being varnished, it is hung up in a drying-room, the capacity of which varies, of course, with the size of the works. The larger establishments have several such rooms, a considerable extent of the buildings being thus occupied. The room is heated to about 170° F. (77° C.) by means of steam-pipes or hot-air pipes, or by means of heated air driven in by a fan, and is ventilated by means of windows, the sashes of which can be opened, or by means of an unpointed tiling to the roof. Much vapour strongly impregnated with acrolein is given off and fills the chamber, rendering the atmosphere very irritating to nose, eyes, and respiratory organs. Some of the vapour condenses as a brown liquid on the walls and panes of the windows. It is a common practice to keep the windows closed at night, and to open them in the mornings for the thorough ventilation of the room. In small establishments, instead of a lighted room, a small but sufficiently capacious dark chamber, more of the nature of an oven, heated in the same way or by hot-water pipes, is in use. The iron doors of such an oven open into the room where the varnishing operations are carried on, so that the atmosphere of this room in which the men work is always more or less charged with irritating vapour. Such an oven as this, if ventilated at all, is ventilated by means of a pipe proceeding from it through the roof of the building.

The process of enamelling leather or pasteboard differs very little from that of making table-covers. The enamel is laid on by means of the scraper before mentioned, and by rubbing it gently on by the hands of the workman. The material is then heated in an oven such as has been described, but so arranged that the material is alid in horizontally upon the sliding shelf on which the varnishing is performed. The varnishing and heating are repeated as often as may be necessary to ensure the proper thickness of enamel.

Brattice cloth, for use in mines, is made by covering coarse hempen

cloth on both sides with a coarse black paint or varnish made of boiled oil and lampblack. It is then dried in a chamber heated to about 120° F. (49° C.) by means of steam-pipes. The evolution of irritating vapour is such that it is said that the windows have to be left open for ventilation for 2 hours before the workmen can enter to remove the cloth.

Such trades as these, unless carried on with due precaution, are apt to give rise to almost intolerable nuisance. The two ordinary sources of nuisance are the manufacture of the varnish and the escape of the pungent acrolein vapours from the drying-rooms and ovens into the external atmosphere. In those works where the only ventilation of the oven is into the workshop itself, when the oven door is opened, although the workmen suffer from the vapour more than they ought to do, the neighbourhood suffers less, probably because much of the vapour is condensed by the cool air of the workshop. The mode of preventing that part of the nuisance which proceeds from the manufacture of the varnish, has already been described. At one works the nuisance proceeding from the escape of vapour from the drying-rooms has been thoroughly obviated by carrying a 10-in. iron pipe from within each room, at its outer wall, down the outside of the building, to a main underground flue, which enters the main flue of the boiler furnace at a point where the flame can reach the vapour, and consume it before it is discharged from the chimney-shaft. A fan may be used to assist the draught.

(*c*) The varnish used in this work is almost invariably copal.

(*d*) A recent patent for the manufacture of leather-cloth shows that, in imitating the surface of leather, oils and varnish are dispensed with. A warm solution of gelatine is prepared, and to this is added an aqueous solution of formaldehyde with the addition of tungstate of soda, castor-oil, glycerine and water glass. The chief effect is to make the gelatine insoluble, so that the surface will be impervious to water or washing operations. This would dry with a moderately dull surface and so have more the appearance of leather and permit of embossing to imitate the grain.

In another method that serves well for comparatively small pieces of goods, sheets of glass are engraved or otherwise prepared with the embossed design the finished cloth is to have, the fluid composition being then run on to the glass, and the cloth finally pressed on to this. When it has dried a little, the cloth with the composition on it is peeled off the glass.

LIGHTNING CONDUCTORS

GENERAL RULES ISSUED BY THE LIGHTNING ROD CONFERENCE IN 1882, REVISED BY THE LIGHTNING RESEARCH COMMITTEE, 1905.

Note.—The Observations of the Lightning Research Committee, 1905, are printed in italics.

THE points, and the rod to which they are attached, constitute the upper terminal, an important part of a lightning conductor. This upper terminal may be constructed with one point; four or more points, all of which should be sharp. If constructed with more than one point, there should be one central point, standing above the others about six inches.

It is desirable to have three or more points beside the upper terminal; these points must not be attached by screwing alone. The rod should be solid and not tubular.

The number of conductors or upper terminals to be specified will depend upon the size of the building, the material of which it is constructed, and the comparative height of the several parts. No general rule can be given for this, but the architect may assume that the space protected is a cone having the point of the lightning conductor for its apex, and a base whose radius is equal to the height of the conductor. He must, however, bear in mind that even an ordinary chimney stack, when exposed, should be protected by an upper terminal connected with the nearest copper tape, inasmuch as accidents often occur owing to the good conducting power of the heated air and soot in a chimney, which, being unconnected with the earth, are strong elements of danger.

The conductor is not to be kept from the building by glass or other insulators, but attached to it by fastenings of *the same metal as itself.*

Conductors should preferentially be fixed down that side of the building which is most exposed to rain. They should be firmly attached, but the holdfasts should not be driven in so tightly as not to allow for the expansion and contraction consequent upon changes of temperature.

To be fixed with holdfasts of the same metal as the conductor in such a manner as to avoid all sharp angles.

These, if of considerable size and importance, should have a copper band round the top, with copper points each about 1 foot long, at intervals of 2 or 3 feet throughout the circumference, and the conductor should, where practicable, be connected with all bands and metallic masses in or near the chimney.

The rods above the band might be curved into an arch provided with three or four points. It is preferable that there should be two lightning rods from the band carried down to earth.

All vanes, finials, ridge ironwork, etc., should be connected with the conductor; it is seldom necessary to interfere with these architectural features by erecting upper terminals, *provided the connection be perfect.*

Copper, weighing not less than 6 oz. per running foot, either in the form of tape or rope of stout wires—no single wire being less than 12 B.W.G.

The dimensions given hold good for main conductors. Subsidiary conductors for connecting metal ridging, etc., to earth may be iron and of smaller gauge, such as No. 4 S.W.G. galvanised iron. The conductivity of the copper is unimportant, except that high conductivity is objectionable. Iron is for this reason much better.

Although electricity of high tension will jump across bad joints, they diminish the efficacy of the conductor, therefore every joint, besides being well cleaned, screwed, scarfed, or riveted, should be thoroughly soldered.

To the height of 10 feet above the ground the conductor may be protected from injury and theft, by being enclosed in an iron pipe inserted some distance into the ground.

The conductor should not be bent

abruptly round sharp corners. In no case should the length of the conductor between two points be more than half as long again as the straight line joining them. Where a string course or other protecting stonework will admit of it, the conductor may be carried straight through, instead of round the projection. In such a case the hole should be large enough to allow the conductor to pass freely, and allow for expansion.

The straighter the run the better. Better to take the rod outside projections than through them, keeping it away from the structure.

As far as practicable it is desirable that the conductor be connected to extensive masses of metal, such as hot water pipes, etc., both internal and external; *but it should be kept away from all soft metal pipes, and from internal gas pipes of every kind.*

It is advisable to connect church bells and turret clocks with the conductors.

It is essential that the lower extremity of the conductor be properly attached to a sheet of copper 3 feet by 3 feet and $\frac{1}{16}$ inch thick, buried in permanently wet earth and surrounded by cinders or coke, or as many yards of the conductor as will be equal to the superficial area of the plate may be laid in a trench filled with coke.

Before giving his final certificate, the architect should have the conductor satisfactorily examined and tested by a qualified person, as injury to it often occurs up to the latest period of the works from accidental causes, and often from the carelessness of workmen.

The Lightning Research Committee (10th April, 1905), put forward the following practical suggestions:—

1. Two main lightning rods, one on each side, should be provided, extending from the top of each tower, spire, or high chimney stack by the most direct course to earth.

2. Horizontal conductors should connect all the vertical rods.

(*a*) Along the ridge, or any other suitable position on the roof.

(*b*) At or near the ground line.

3. The upper horizontal conductor should be fitted with aigrettes or points at intervals of 20 or 30 feet.

4. Short vertical rods should be erected along minor pinnacles and connected with the upper horizontal conductor.

5. All roof metals, such as finials, ridging, rain-water and ventilating pipes, metal cowls, lead flashings, gutters, etc., should be connected to the horizontal conductors.

6. All large masses of metal in the building should be connected to earth either directly or by means of the lower horizontal conductor.

7. Where roofs are partially or wholly metal lined, they should be connected to earth by means of vertical rods at several points.

8. Gas pipes should be kept as far away as possible from the positions occupied by lightning conductors, and as an additional protection the service mains to the gas meter should be metallically connected with house services leading from the meter.

The relative conductivity of the cheaper metals is given as follows:—

Lead, 1; tin, $1\frac{1}{2}$; iron, 2; zinc, 4; copper, 12. Copper is the best material of all the ordinary metals. As it is not liable to corrosion, and is very durable, it may be recommended as the most suitable for an efficient lightning conductor.

It is absolutely necessary that a conductor be solid, pliable and durable, and not too costly for general application. The only construction which complies with all these conditions is copper tape (variously called band, strip or ribbon). Therefore tape is in every respect to be preferred to rope, the latter being a series of thin wires twisted together in the form of a rope.

An older form of conductor, now obsolete, known as "Spratt's Patent," is to be found on some old buildings. It consists of copper wires plaited in a flat open mesh work, sometimes with a zinc wire interlaced. This form is

absolutely dangerous, and should not be retained.

It is important to note, that when nails are used for fixing the conductor they must be of solid wrought-copper only.

Copper tape is made in several sizes to suit the varying requirements, and practically in any lengths.

LITHOGRAPHY.

THE following are the principles on which the art of lithography depends: the facility with which calcareous stones imbibe water; the great disposition they have to adhere to resinous and oily substances; and the affinity between each other of oily and resinous substances, and the power they possess of repelling water, or a body moistened with water. Hence when drawings are made on a polished surface of calcareous stone, with a resinous or oily medium, they are so adhesive that nothing short of mechanical means can effect their separation from it; and whilst the other parts of the stone take up the water poured upon them, the resinous or oily parts repel it. When, therefore, over a stone prepared in this manner, a coloured oily or resinous substance is passed, it will adhere to the drawings made as above, and not to those parts of the stone which have been watered. The ink and chalk used in lithography are of a saponaceous quality; the former is prepared in Germany from a compound of curd or common soap, pure white wax, a small quantity of tallow and shellac, and a portion of lampblack, all boiled together, and when cool, dissolved in distilled water. The chalk for the crayons used in drawing on the stone is a composition consisting of the ingredients above mentioned. After the drawing on the stone has been executed, and is perfectly dry, a very weak solution of nitric acid is poured upon the stone, which not only takes up the alkali from the chalk or ink, as the case may be, leaving an insoluble substance behind it, but lowers, to a small extent, that part of the surface of the stone not drawn upon, thus preparing it to absorb water with greater freedom. Weak gum-water is then applied to the stone, to close its pores and keep it moist. The stone is now washed with water, and the printing-ink is applied with rollers, as in letterpress printing; after which it is passed, in the usual

way, through the press, the processes of watering and inking being repeated for every impression. If the work is inclined to get smutty, a little vinegar or stale beer should be put into the water that is used to damp the stone.

There is a mode of transferring drawings made with the chemical ink on paper prepared with a composition of paste, isinglass, and gamboge, which, being damped, laid on the stone, and passed through the press, leaves the drawing on the stone, and the process above described for preparing the stone and taking the impressions is carried into effect.

Lithographic Stones.—Stones are prepared for chalk drawings by rubbing two together, with a little silver sand and water between them, taking care to sift the sand to prevent any large grains from getting in, by which the surface would be scratched. The upper stone is moved in small circles over the under one till the surface of each is sufficiently even, when they are washed, and common yellow sand is substituted for the silver sand, by which means is procured a finer grain. They are then again washed clean, and wiped dry. It will be found that the upper stone is always of a finer grain than the under one. To prepare stones for writing or ink drawings, they are rubbed with brown sand, washed, and rubbed with powdered pumice; the stones are again washed, and each polished separately with a fine piece of pumice or water Ayr-stone. Chalk can never be used on the stones prepared in this manner. The same process is followed in order to clean a stone that has already been used.

Lithographic Ink. — Tallow, 2 oz.; virgin wax, 2 oz.; shellac, 2 oz.; common soap, 2 oz.; lampblack, ½ oz. The wax and tallow are first put in an iron saucepan with a cover, and heated till they ignite; whilst they are burning the soap must be thrown in, a small piece at a time, taking care that the first is melted before a second is put in. When all the soap is melted, the ingredients are allowed to continue burning till they are reduced one third in volume. The shellac is now added, and as soon as it is melted, the flame must be extinguished. It is often necessary in the course of the operation to extinguish the flame and take the saucepan from the fire, to prevent the contents from boiling over; but if any parts are not completely melted, they must be dissolved over the fire without being again ignited. The black is next added. When it is completely mixed the whole mass should be poured out on a marble slab, and a heavy weight laid upon it to render its texture fine. The utmost care and experience are required in making both the ink and chalk, and even those who have had the greatest practice often fail. Sometimes it is not sufficiently burned, and when mixed with water appears slimy; it must then be remelted and burned a little more. Sometimes it is too much burned, by which the greasy particles are more or less destroyed; in this case it must be remelted, and a little more soap and wax added. This ink is for writing or pen-drawing on the stone. The ink for transfers should have a little more wax in it.

Lithographic Chalk.—Common soap, 1½ oz.; tallow, 2 oz.; virgin wax, 2¼ oz.; shellac, 1 oz.; lampblack, ¼ oz. Mix as for *lithographic ink.*

Lithographic Transfer Paper. Dissolve in water ¼ oz. gum tragacanth. Strain and add 1 oz. glue and ½ oz. gamboge. Then take 4 oz. French chalk, ½ oz. old plaster of Paris, 1 oz. starch; powder, and sift through a fine sieve; grind up, with the gum, glue, and gamboge; then add sufficient water to give it the consistence of oil, and apply with a brush to thin sized paper.

Transferring.—The drawing or writing made on the prepared side of the transfer paper is wetted on the back, and placed, face downwards, on the stone, which must previously be

very slightly warmed, say to about 125° F. Pass the stone through the press four or five times, then damp the paper, and carefully remove it.

Drawing on Stone.—The subject should first be traced on the stone in red, great care being taken not to touch the stone with the fingers. Or the drawing may be done by means of a black-lead pencil; but this is objectionable, as it is difficult to distinguish the line from that made by the chalk or ink. Then having a rest to steady the hand, go over the drawing with the chalk, pressing it with sufficient firmness to make it adhere to the stone. For flat tints, considerable practice is necessary to secure an even appearance, which is only to be obtained by making a great many faint strokes over the required ground. Lights may either be left, or, if very fine, can be scraped through the chalk with a scraper. If any part is made too dark, the chalk must be picked off with a needle down to the required strength.

Etching-in for Printing on Stone.—Dilute 1 part of aquafortis with 100 parts of water. Place the stone in a sloping position, then pour the solution over it, letting it run to and fro until it produces a slight effervescence. Then wash the stone with water, and afterwards pour weak gum-water over it. The acid, by destroying the alkali on the lithographic chalk, causes the stone to refuse the printing-ink except where touched by the chalk; the gum-water fills up the pores of the stone, and thus prevents the lines of the drawing from spreading. When the stone is drawn on with ink, there must be a little more acid used with the water than when the drawing is made with chalk. The roller charged with printing-ink is then passed over the stone, which must not be too wet, and the impression is taken as before described.

Engraving on Stone. — The stone must be highly polished; pour the solution of aquafortis and water over it, washing it off at once. When dry, cover with gum water and lampblack; let this dry, then etch with a needle, as on copper. It is necessary to cut the surface of the stone through the gum, the distinction of light and dark lines being obtained by the use of fine or broad-pointed needles. Rub all over with linseed-oil, and wash the gum off with water. The lines on the stone will appear thicker than they will print.

Imitating Woodcuts on Stone. — Cover with ink those parts meant to be black; scratch out the lights with an etching needle; the lines which come against a white background are best laid on with a very fine brush and lithographic ink.

Inking Roller.—Fasten a smooth piece of leather round a wooden roller of the required length.

Removing the Transfer.—The existing transfer is ground away by rubbing it with another piece of stone, putting sand between, like grinding flour between the millstones, using finer sand as it gradually wears away; then it is ground with rottenstone till of the requisite fineness for the next transfer.

Transferring from Copper to Stone. In transferring from copper to stone use prepared paper, that is, ordinary unsized paper, coated with a paste of starch, gum-arabic and alum. Take about 60 parts of starch, and mix with water to a thinnish consistency over a fire; have 20 parts of gum ready dissolved, and also 10 parts of alum dissolved; when the starch is well mixed, put in the gum and alum. While still hot, coat the paper with it in very even layers, dry, and smooth out. Take an impression from the copper with the transfer ink; lay the paper on the stone, damp the back thoroughly with a sponge and water, and pass through the litho-press. If all is right the impression will be found transferred to the stone, but it will of course require preparing in the usual manner. The great advantage gained is that very many more impressions may be printed from stone than from a copper-plate and very much quicker.

Algraphy.—This is a lithographic process in which an aluminium plate (about $\frac{1}{32}$ in. thick) is used instead of a stone. The plate is supported on a suitable bed-plate or base, this latter occupying the space usually filled by the stone, so that the ordinary lithographic printing-presses can work with this new process. A bed-plate for Algraphy, for a printing surface of 26 in. by 20 in., costs 5*l.* while the cost of fitting it is practically *nil.*

There is every probability of Algraphy having a considerable future, and it is already having the favour of some of our largest publishers issuing coloured plates. The chief advantage possessed by the Algraphic plate is its extreme portability, the ease of handling, the small space taken and the ease of storage, and its not being breakable.

To instal Algraphy in a lithographic works the following appliances are necessary, viz.: some Algraphic plates, a bed-plate for the machine, rubber rollers, acid-bath, etching solutions, counter-etching solutions, washing-out fluid, pumice powder, felts and squeegee, brushes, and pincers. At the present time the English patents are in the hands of Algraphy, Ltd., Peckham, London, who supply all the foregoing and any accessories required.

The bed-plate is of cast-iron, resembling a very low table, being $3\frac{1}{4}$ in. high, and occupying the space prepared for litho stones. It is put into this space and remains there, always in readiness to receive the plates. What has to be borne in mind is that the bed-plate, having a gripping and stretching arrangement for the plate makes the printing surface a little less in breadth than the stone previously used. A bed is needed for each machine and one for the transfer-press though a stone may be used for the latter.

The inking rollers are best of india-rubber, instead of the usual glazed leather. The latter becomes so smooth that it injuriously polishes the plate, besides having other faults. Nap leather is better, but not equal to rubber, nor as durable.

The acid-bath is to clean the aluminium plates, whether new or used. They are immersed 6 to 10 hours. Pincers are used to handle the plates in the bath.

Pumice powder which has to be of an even fine grain (not dust) is used for rubbing off. If done by hand a wood rubber about 6 in. by 3 in., with the face covered with felt, is used.

In printing, or in fact during all processes, cleanliness is essential: and as with lithography, warmth is requisite. 65° Fahr. is the best temperature, but greater heat, as in hot weather, is not objectionable.

To use the acid bath, fill it two-thirds full of water, then fill up with nitric acid, free from chlorine. This bath will serve (without emptying) for about 6 months, but requires acid to be added occasionally.

Aluminium is the only metal that must enter the bath, and for this reason the pincers are made of this material. The period of immersion may be 6 to 7 hours in summer and 5 hours longer in winter. The acid has no destructive action on the metal. The plates are kept separate in the bath; and, when taken out, well washed with water, using a piece of felt, then swilled and put to dry. For small plates a quicker process is possible, using the company's special plate-cleaning fluid.

When the plates are thus chemically cleaned they are "roughed" or "ground" with pumice powder. The object to be attained is a slight roughening of the surface to afford a "key" for the ink, and so give the design durability, at the same time favouring the distribution of moisture where the design does not touch. The pumice is applied with the rubber described, a circular, heavy and even pressure being given. It takes a full half hour to "grind" a plate 36 in. square, and some skill, or rather care, is required to do the work perfectly. Good grinding is essential to good work.

When a plate has been used and is finished with, it has the old work well washed off with turpentine, and is then put in the acid bath for about 12 hours. After this it is rinsed and "ground" with fine silver sand or glass powder, and finished with pumice. This, which is termed a "graining" process, is best done by a simple machine that can be obtained.

The preparation of the design on the plate will, of course, give good or poor results according to the ability of the artist, or the printer, or both. Sweating, which is so great a cause of trouble with stone, does not occur with Algraphic plates. The various methods of applying the design, whether direct, or indirect, or transfer, and the various materials that may be used, can be learned from the company's pamphlet.

When the design is made, the plate is etched with etching fluid (weak for originals, or strong for transfer), the washing-out fluid being used as required. Proofing then follows, and corrections as required. Corrections in this work present no difficulty.

In storing original plates, a rack should be provided, fixed in the machine room or other temperate place, never in an underground cellar. Before being put away it should be rolled well up, gummed thinly, dried, then washed-out with turpentine (without rubbing) over the gum, dried again, and then gone over (the whole plate) with washing-out fluid. This protects the plate from smudging etc., while the metal is protected from damp. Plates of one set may be interleaved with paper and tied up in parcels. When required for use again, rinsing with water and gumming them are all that is necessary.

The process of Algraphy can be used for photo-reproduction, either line or half-tone. Transfers may also be rubbed on the plate, rolled on, or produced by means of the washing-out fluid. The latter is surest and quickest and, therefore, most used.

LUBRICANTS.

AN efficient lubricant must exhibit the following characteristics: (1) Sufficient "body" to keep the surfaces between which it is interposed from coming into contact; (2) the greatest fluidity consistent with (1); (3) a minimum coefficient of friction; (4) a maximum capacity for receiving and distributing heat; (5) freedom from tendency to "gum" or oxidise; (6) absence of acid and other properties injurious to the materials in contact with it; (7) high vaporisation- and decomposition-temperatures, and low solidification-temperature; (8) special adaptation to the conditions of use; (9) freedom from all foreign matters. The modern methods of testing the lubricating qualities of oils are directed to a discovery of the following points: (1) Their identification and adulteration; (2) density; (3) viscosity; (4) "gumming"; (5) decomposition-, vaporisation-, and ignition-temperatures; (6) acidity; (7) coefficient of friction. The 1st and 2nd stages are described very fully in an original article by Dr. Muter in Spons' 'Encyclopædia.' The viscosity and gumming tendency may be simultaneously detected by noting the time required by a drop to traverse a known distance on an inclined plane. A 9 days' trial gave the following result: Common sperm-oil, 5 ft. 8 in. on the 9th day; olive-oil, 1 ft. 9$\frac{1}{8}$ in. on the 9th day; rape-oil, 1 ft. 7$\frac{3}{8}$ in. on the 8th day; best sperm-oil, 4 ft. 6$\frac{1}{4}$ in. on the 7th day; linseed-oil, 1 ft. 6$\frac{1}{4}$ in. on the 7th day; lard-oil, 11$\frac{3}{8}$ in. on the 5th day. The day given is in each case that on which the oil ceased to travel. There are several ways of applying the plane test. A very simple and general test of fluidity is to dip blotting-paper in the oil, and hold it up to drain; symmetrical drops indicate good fluidity; a spreading tendency, viscosity. Retention of the oil on the paper for

some hours at 200° F. (93⅓° C.), or for some days at ordinary temperatures, will show the rate of gumming. (Thurston.)

Putting aside the commoner characteristics of a good oil, such as the absence of acidity either natural or artificial, and the absence of gumminess, one of the most commonly believed ideas is, that an oil of high specific gravity is the best for lubricating purposes. Although this may be true in certain cases, yet from observations and experiments made over a long period it appears that they are not always the best, and that the point upon which we must rely is the viscosity. To test this, a French burette graduated into 100 c.c. is most useful. The burette is fitted on a stand and filled with the oil to be tested; after allowing all bubbles of the air to separate, it is permitted to run through, and the time it takes to do so is carefully noted. At the close of the experiments, it will be found that the viscosities are directly proportional to the time taken; thus, if a mineral oil takes 15 seconds, and rape-seed-oil 45 seconds, the viscosity of rape-seed-oil is 3 times that of the mineral. The temperature may be either 60° or 90° F. (15½° or 32° C.), but the latter is preferable, as the oil may be subjected to that temperature when in use. Now, if an oil of very high viscosity, such as castor or rape-seed, were used to lubricate an engine of low horse-power, in all probability, instead of reducing the friction to a minimum, it would itself become a source of resistance, and increase the evil. Conversely, if an oil of very low viscosity were used to lubricate an engine of high horse-power, the friction would be but slightly if at all reduced. Hence, looking at extreme cases, there exists a marked connection between viscosity and horse-power, and to ensure perfect lubrication, the viscosity must gradually increase with the ponderousness of the machinery. It is stated by one authority that the best method for mixing oils with this object is to take a basis of American or Scotch mineral oil at 0·885 to 0·903 sp. gr., and add olive, lard, rape-seed or castor oil to work up the viscosity. Olive and lard oils, when mixed with mineral oils in proportions of 10, 20, 25, and so on up to 75 per cent., are about equal in value as lubricants of the lighter class of machinery. Rape-seed-oil in like proportions is valuable where the machinery is of a heavier kind, or where the lubricant has to be used throughout on works in which the machines vary much; but in such a case it is better to divide them into classes, and use a special oil for each class. Castor-oil, mixed with mineral oil in varying proportions, may be used in the case of the most ponderous machinery. Cold mixed oils are considered preferable to those mixed at a temperature over 100° F. (38° C.).

The suitability of a lubricating medium depends upon the character of the work being done, and is not constant. In order to procure the nearest possible approach to what is required for special purposes, many compounds are now in the market, being mainly mixtures of mineral and animal or vegetable oils in proportions calculated to develop the particular characteristics required. The general experience gained of various oils used for lubricating tends to the following results: (1) A mineral oil flashing below 300° F. (149° C.) is unsafe, on account of causing fire; (2) a mineral oil evaporating more than 5 per cent. in 10 hours at 140° F. (60° C.) is inadmissible, as the evaporation creates a viscous residue, or leaves the bearing dry; (3) the most fluid oil that will remain in its place, fulfilling other conditions, is the best for all light bearings at high speeds; (4) the best oil is that which has the greatest adhesion to metallic surfaces, and the least cohesion in its own particles: in this respect, fine mineral oils are 1st, sperm-oil 2nd, neat's-foot oil 3rd, lard-oil 4th; (5) consequently the finest mineral oils are best for light bearings and high velocities; (6) the best animal oil to give body to fine mineral oils is

sperm-oil; (7) lard- and neat'sfoot-oils may replace sperm-oil when greater tenacity is required; (8) the best mineral oil for cylinders is one having sp. gr. 0·893 at 60°F. (15½°C.), evaporating-point 550°F. (288°C.), and flashing-point 680°F. (360°C.); (9) the best mineral oil for heavy machinery has sp. gr. 0·880 at 60° F. (15½° C.), evaporating-point 443° F. (229° C.), and flashing-point 518° F. (269° C.); (10) the best mineral oil for light bearings and high velocities has sp. gr. 0·871 at 60° F. (15½° C.), evaporating-point 424° F. (218° C.), and flashing-point 505° F. (262° C.); (11) mineral oils alone are not suited for the heaviest machinery, on account of want of body, and higher degree of inflammability; (12) well-purified animal oils are applicable to very heavy machinery; (13) olive-oil is foremost among vegetable oils, as it can be purified without the aid of mineral acids; (14) the other vegetable oils admissible, but far inferior, stated in their order of merit, are gingelly-, ground-nut-, colza-, and cotton-seed-oils; (15) no oil is admissible which has been purified by means of mineral acids.

As the result of numerous experiments, Veitch Wilson is convinced that mineral oils are, if used alone, unsatisfactory lubricants; but bearing in mind the natural and almost ineradicable tendency of mineral oils to develop acid, and of vegetable oils by the absorption of oxygen to gum and clog the bearings and to induce spontaneous combustion, bearing also in mind the fact that mineral oils can now be obtained in every respect as safe as the finest animal oils, and that the admixture of mineral oil with animal or vegetable oil neutralises the acidity in the one case and the acidity and oxidising tendency in the other, he is of opinion that the safest, most efficient, and most economical lubricants for all manner of bearings are to be produced from a judicious mixture of animal or vegetable with good mineral oils. With regard to cylinder lubrication, the peculiar conditions are the liberation of natural acids from vegetable and animal fats and oils by the action of steam and heat, the action of these acids on the cylinders, and the evidence that as these acids are constituents of all animal and vegetable fats and oils, they cannot be removed by any process of refining. One of the lubricants largely in use is tallow, but there is conclusive evidence that it is the cause of considerable injury to the engine cylinders. From the mass of evidence he has been able to collect upon the subject, he is convinced that if care was exercised in the selection of the oil, and equal care in its preparation and application, hydrocarbon oil would be found thoroughly efficient as a cylinder lubricant, absolutely harmless, and much more economical than tallow. The bulk of the cylinder oils now before the public are of American origin: they are usually sold pure, but sometimes a small percentage of animal or vegetable matter is added in order to increase their lubricating properties, and in his experience, this has always been attended with most favourable results. The thickest oil that can be introduced into a cylinder is the best. Hot-air engines may be lubricated on precisely the same principles as steam cylinders, but gas-engines present a new and special feature, as in their case the lubricant is not only subjected temporarily to the intense heat of the explosion, but also comes into direct contact with the flame, and is liable to be decomposed or carbonised thereby. If, therefore, animal or vegetable fats and oils are objectionable in steam cylinders, they are much more so in the cylinders of gas-engines; and in the case of gas-engines he would most emphatically protest against the use of any but pure hydrocarbon oils without any admixture. ('Colliery Guardian.')

The lubricating power of a mineral oil increases with its specific gravity. Wherever, therefore, in machinery there is great friction with heavy pressure, only *heavy* mineral oils should be employed, and if they are properly

prepared—i.e. free from resins and acids—they retain their lubricating power at any temperature. Animal and vegetable oils, on the contrary, however pure, gradually lose this power, and owing to the oxidising action of the air, become thick, gummy, and eventually quite stiff, and hence continual oiling and frequent cleaning become necessary. The heavy mineral oils have not this tendency to become thick under the same influences. Then again, at a low temperature animal and vegetable oils become thick, or even solid, whereas mineral oil always remains liquid, and even the greatest cold only makes it slightly thicker, but never solid. The chief advantage, however, of the mineral oils is that they do not act upon iron like those of animal and vegetable origin. As already stated, the latter are composed of fatty acids and glycerine, a combination which is broken up into its constituent parts by superheated steam. (On this fact the manufacture of stearine and glycerine depends.) The same decomposition, however, takes place, although only gradually, under the influence o atmospheric moisture, even at the ordinary temperature. The free fatty acids attack the metals with which they are in contact, forming the so-called metallic soaps, and this takes place irrespective of the presence of steam. The affinity of the fatty acids for ferric oxide is indeed so great, that it seems as if the iron dissolved in them at the moment of contact. ('Leip. Färb. Zeit.')

All the mineral oils—and also sperm-, lard- and neat'sfoot-oils—appear to reach a nearly uniform coefficient of friction at very greatly different degrees of heat in the bearings. Several kinds of the best mineral oils and sperm- and lard-oils, show a uniform coefficient of friction at the following degrees of heat:—

Temperature at which the Coefficient of Friction is the same.

Downer Oil Co., 32°, Machinery (an exceedingly fluid oil)	76° F.
Do. Light Spindle	105° F.
Do. Heavy Spindle	125° F.
Various samples of Sperms	96°-114° F.
Leonard and Ellis Valvoline Spindle	127° F.
Do. White Valvoline Spindle	122° F.
Do. White Loom	111° F.
Olney Bros., German Spindle	112° F.
,, ,, A Spindle	107° F.
Neat'sfoot	170° F.
Lard-oil	180° F.

Lubrication seems to be effective in inverse ratio to viscosity—that is, the most fluid oil that will stay in its place is the best to use. Lard-oil heated to 130° F. (54½° C.) lubricates as well as sperm at 70° F. (21° C.), or the best mineral oil at 50° F. (10° C.). But of course it is a great waste of machinery to work oil of any kind up to an excessive heat; and there must be the least wear in the use of oil that shows the least coefficient of friction at the lowest degree of heat.

So far as laboratory experiments may serve as a guide in practice, it therefore appears that fine mineral oils may be made to serve all the purposes of a cotton-mill, and such is the practice in some of the mills that show the very best results in point of economy.

Next, that the best animal oil to mix with a fine mineral oil, in order to give it more body, is sperm-oil; this, again, accords with the practice of many of the mills in which the greatest economy is attained.

Lard- and neat'sfoot-oil are used to give body to mineral oil in some of the best mills; but the results of work seem not to warrant this practice, unless there is some peculiarity in the machinery that makes it more difficult to keep a less viscous or tenacious oil on the bearings.

It appears that all varieties of mineral oils are or have been used in print cloth-mills, and are all removed in the

process of bleaching, as practised in print-works.

All mineral oils stain more or less, and give more or less difficulty to the bleacher when dropped upon thick cloth, or cloth of a close texture. On this point we have been able to establish no positive rule; but as very many kinds are and have been used in mills working on such cloths, and are removed, we are inclined to the belief that this question is not of as great importance as it has been assumed to be. ('Scient. Amer.')

Axle-Grease.—

(1) English railway axle-grease.

	Summer.	Winter.
Tallow	504 lb.	420 lb.
Palm-oil	280 „	280 „
Sperm-oil	22 „	35 „
Caustic soda	120 „	126 „
Water	1370 „	1524 „

(2) German railway-grease.

Tallow	24·60
Palm-oil	9·80
Rape-seed-oil	1·10
Soda	5·20
Water	59·30

(3) Austrian railway-grease.

	Tallow	Olive oil	Old grease.
Winter	100	20	13
Spring and autumn	100	10	10
Summer	100	1	10

(4) Frazer's axle-grease is composed of partially saponified rosin-oil—that is, a rosin-soap and rosin-oil. In its preparation, ½ gal. of No. 1 and 2½ gal. of No. 4 rosin-oil are saponified with a solution of ½ lb. sal-soda dissolved in 3 pints water and 10 lb. sifted lime. After standing for 6 hours or more, this is drawn off from sediment, and thoroughly mixed with 1 gal. of No. 1, 3½ gal. No. 2, and 4½ gal. No. 3 rosin-oil. This rosin-oil is obtained by the destructive distillation of common rosin, the products ranging from an extremely light to a heavy fluorescent oil or colophonic tar.

(5) Pitt's car-, mill-, and axle-grease is prepared as follows:—

Black oil or petroleum residue	40 gal.
Animal grease	50 lb.
Rosin, powdered	60 lb.
Soda lye	2½ gal.
Salt, dissolved in a little water	5 lb.

All but the lye are mixed together, and heated to about 250° F. (121° C.). The lye is then gradually stirred in, and in about 24 hours the compound is ready for use.

(6) Booth's railway-grease.—Water, 1 gal.; clean tallow, 3 lb.; palm-oil, 6 lb.; common soda, ½ lb.; or, tallow, 8 lb.; palm-oil, 10 lb. To be heated to about 212° F., and to be well stirred until it cools to 70° F.

(7) Anti-friction grease.—100 lb. tallow, 70 lb. palm-oil. Boiled together, and when cooled to 80° F., strain through a sieve, and mix with 28 lb. of soda and 1½ gal. of water. For winter, take 25 lb. more oil in place of the tallow. Or black-lead, 1 part; lard, 4 parts.

(8) Railway-grease.—For summer use—1¾ cwt. tallow, 1¼ cwt. palm-oil; for autumn and spring—1½ cwt. each tallow and palm-oil; for winter—1¼ cwt. tallow, 1¾ cwt. palm-oil. Melt the tallow in an open pan, add the palm-oil, and remove the fire the moment the mixture boils; stir frequently while cooling, and when the temperature has fallen to about 100° F. (38° C.), run it through a sieve into a solution of soda (56 to 60 lb.) in 3 gal. water, and stir together thoroughly.

(9) Railway- and waggon-grease.—The first of these consists essentially of a mixture of a more or less perfectly formed soap, water, carbonate of soda, and neutral fat, and is used on the axles of all locomotives, railway-carriages, and trucks that are provided with axle-boxes; while the second is a soap of lime and rosin-oil, with or without water, and is used on all railway-trucks unprovided with axle-boxes, and for ordinary road vehicles.

The requisites for a good "locomotive-grease" for high velocities are: (1) a suitable consistency, such that it will neither run away too rapidly, nor

be too stiff to cool the axles; (2) lasting power, so that there may be as little increase of temperature as possible in the axles, even at high speeds; (3) a minimum of residue in the axle-boxes.

In practice, it is found that a grease containing 1·1 to 1·2 per cent. soda (100 per cent.) gives the best result. The process of manufacture is very simple; Morfit's soap-pans, provided with stirrers, are the most suitable vessels for the purpose. The fats, usually tallow and palm-oil, are heated to 180° F. (82° C.), and into them are run the carbonate of soda and water heated to 200° F. (93⅓° C.); the whole is well stirred together, and run into large tubs to cool slowly. Many railway companies buy a curd-soap made from red palm-oil, dissolve it in water, and add thereto enough tallow and water to bring the composition of the whole to the desired point. It is usual to allow 2½ per cent. for loss by evaporation of the water during the manufacture. The composition has to be slightly varied according to the season of the year; the following formulæ for mixing have stood the test of successful experiment; the summer one ran 1200 miles. It should be carefully borne in mind that a careful analysis of locomotive-grease is no test whatever of its practical value, which can only be determined by actual experiment.

—	Summer.	Winter.
	Per cent.	Per cent.
Tallow . .	18·3	22·3
Palm-oil . .	12·2	12·2
Sperm-oil . .	1·5	1·2
Soda crystals .	5·5	5·0
Water . . .	62·5	59·3
	100·0	100·0

The "waggon-grease" is thus prepared: A good milk of lime is made, and run through several overflow-tubs, where all grit is deposited; it is then drained on canvas. If the grease is to be made without water, the paste must be agitated with rosin-spirit, which expels the water, and it is then thinned with a further quantity of rosin-spirit. The aqueous milk of lime, or the mixture of lime and rosin-spirit, is then stirred, together with a suitable quantity of rosin-oil, in a tight barrel furnished with a shaft and stirrers, without the application of heat, after which the whole is run out into barrels to set. Many other ingredients are often stirred in, such as "dead oil," petroleum residues, graphite, sea-weed jelly, silicate of soda, oil refiners' foots, micaceous ores, steatite, Irish moss, etc. (Spons' 'Encyclopædia.')

(10) Waggon-axle.—Hard crude rosin-oil, 2 gal.; anthracene grease oil, 2½ gal.; water, 1 gal.; quicklime, 2½ lb. Slake the lime in the water, then strain through a sieve. Stir in the rosin-oil, allow to stand one day, then pour off the water that lies on top. Into the remaining mass stir the anthracene grease oil. Heat the whole to 240° F., and stir until of a uniform consistency. When cool it is ready for use.

(11) Carriage-grease.—Melt together in an open boiler at a moderate heat, one part of red rosin and one part rendered tallow, and when they are well mixed stir in one part of caustic soda lye and continue stirring until the mixture ceases to rise. Now stir in one part of cotton-seed-oil and boil the whole for a quarter of an hour. While it is hot strain well, and on cooling it is fit for use.

(12) Tram-axle.—Equal parts by weight of "hard" rosin-oil, 0·885 mineral oil and slaked lime. Thoroughly mix. This is a good grease.

(13) Grease melting at 120° F.—8 parts filtered cylinder-oil, 1 part tallow, 1 part ceresine wax. Melt tallow and wax together, then add the oil, stirring well all the time.

(14) Grease melting at 150° F.—3 parts filtered cylinder-oil, 4 parts

0·903 to 0·907 mineral oil, 1 part tallow, 2 parts ceresine wax. Prepare as (13).

(15) Grease melting at 215° F.—3 parts petroleum jelly, 2 parts castor-oil (or seal-oil), 2 parts oleate of alumina, 3 parts ceresine wax. Prepare as (13).

(16) Cart-grease.—Mix together 10 parts heavy paraffin oil, 10 parts resin oil, and 5 parts oleic acid. Into this mixture dissolve 10 parts of tallow separately. Make a caustic lye by mixing 1½ part quicklime with 1 part of soda lye of 40° Be., and stir into the mixture until complete saponification takes place.

Lubricants containing Plumbago. (1) *Grease for Wooden Axles.*—Put 10 lb. of quicklime into a tub, and pour water over to just cover well. Let stand a day or two, stirring occasionally. Strain or pass through a fine sieve. Mix in 15 quarts of common rosin-oil, and let stand one day. Pour off the water, then add 10 gal. of coal-tar grease-oil and 10 lb. plumbago. Heat the whole gently until amalgamation takes place.

(2) *Plumbago-grease.*—This is a good compound as a heavy lubricant. Render some tallow to free it from rancidity, and when melted add 1 part of plumbago to every 4 parts of tallow, and mix well. To each 100 lb. while fluid add 4 lb. of camphor.

(3) *Lubricants for Wood.*—Wood screws or any wood surfaces that rub can be successfully lubricated with plain plumbago (black-lead). It can be applied mixed with water to the consistency of paint, or it will do if it can be dusted on dry.

(4) To a quantity of good lard, rendered semi-fluid (but not liquid) by gentle heat in an iron pan, is gradually added ¼ part by weight of finely powdered and sifted graphite (black-lead), with careful and continued stirring till the mass is homogeneous and smooth; the heat is then steadily increased till the compound liquefies, when it is allowed to cool, the stirring having been meanwhile kept up unceasingly.

(5) 8 lb. tallow, 10 lb. palm-oil, 1 lb. graphite (black-lead).

(6) 2¼ lb. lard, 1 oz. camphor, ½ lb. graphite (black-lead). Rub up the camphor into a paste with part of the lard in a mortar, add the graphite and the rest of the lard, and intimately mix.

Hot neck Grease.—(1) Dissolve 2½ lb. sugar of lead (lead acetate) in 16 lb. melted but not boiling tallow, and add 3 lb. black antimony, stirring the mixture constantly till cold. For cooling necks of shafts.

(2) Common.—Heat and stir together 16 lb. dark cylinder-oil, 12 lb. hard run oil, 2 lb. brown grease, ½ lb. wool-pitch, ½ lb. dry slaked lime.

(3) Better quality.—Cut into shreds 8 lb. of soap and dry it. Mix together 12 lb. of filtered cylinder oil and 12 lb. 0·915 petroleum oil and heat them to 240° F. Add the soap, and heat until the soap is dissolved. When this is done, allow to cool and it is ready for use.

(4) Maguire uses for hot neck grease—

Tallow	16 lb.
Fish	60 lb.
Soapstone	12 lb.
Graphite	9 lb.
Saltpetre	2 lb.

The fish (whole) is steamed, macerated, and the jelly pressed through fine sieves for use with the other constituents.

Lubricating Oils and Mixtures.—(1) Common heavy shop-oil. 30 pints petroleum, 20 of crude paraffin-oil, 20 of lard-oil, 9 of palm-oil, 20 of cotton-seed-oil.

This is suited for various parts of machinery. The ingredients should be mixed at a temperature of about 100° F.

(2) Heavy lubricating.—4 parts of lard-oil, 6 parts olive-oil, 2 parts cocoanut-oil; all by weight.

(3) Heavy lubricating.—1 part lard-oil, 2 parts olive-oil, 1 part cocoanut-oil, and 1 part 0·908 mineral-oil; all by weight.

(4) Heavy engine.—7 parts lard-oil, 18 parts 0·908 mineral-oil; by weight.

(5) Hendricks' lubricant is prepared from whale- or fish-oil, white-lead, and petroleum. The oil and white-lead are, in about equal quantities, stirred and gradually heated to between 350° and 400° F. (177° to 204½° C.), then mixed with a sufficient quantity of the petroleum to reduce the mixture to the proper gravity.

(6) Munger's preparation consists of—

Petroleum	1 gal.
Tallow	4 oz.
Palm-oil	4 oz.
Graphite	6 oz.
Soda	1 oz.

These are mixed and heated to 180° F. (82° C.) for an hour or more, cooled, and after 24 hours well stirred together.

(7) A somewhat similar compound is prepared by Johnson as follows:—

	Liquid.	Solid.
Petroleum (30° to 37° gravity)	1 gal.	1 gal.
Crude paraffin . .	1 oz.	2 oz.
Wax (myrtle, Japan and gambier) . .	1½ oz.	7 oz.
Bicarbonate of soda .	1 oz.	1 oz.
Powdered graphite	3 to 5 oz.	8 oz.

Dynamo-oil. — 1 part refined cocoanut-oil, 1 part 0·885 mineral-oil, 2 parts 0·908 mineral-oil. Put the cocoanut-oil in a steam jacketed pan, then run in the mineral-oils. Heat to 170° F., and put on blower for about a quarter of an hour. Stop the heat, and let settle; it is then finished. The mixture forming this lubricant can be varied by increasing the proportion of cocoanut-oil up to double that given above.

Cylinder-oil. — 3 parts filtered cylinder-oil, 2 parts black cylinder-oil, 1 part thickened rape-oil. Heat to 200° F. in steam jacketed pan for half an hour, stirring well. When settled, it can be run into barrels while warm. If desired, half the rape-oil can be omitted and this quantity of lard-oil added. What is known as A and B blend consists of 9 parts steam-refined cylinder-oil, 3 parts thickened rape-oil and 3 parts lard-oil. This is A blend. The B blend consists of 9, 4, and 4 parts respectively.

Oils for small and delicate Mechanisms.—*Watchmakers.*—(*a*) One of the most delicate articles to lubricate is a watch, and special precautions are necessary to be observed in selecting a material, or combination of materials, for this purpose. Some find porpoise-oil to give most uniform satisfaction, though perhaps rather thin for certain parts. To get rid of acid in the oil, the latter should be washed in filtered water, to which a little soda carbonate has been added; after settling, the oil is poured off, and heated to 212° to 225° F. (100° to 107° C.) for an hour or so with constant stirring. The plan of placing lead shavings in oil to neutralise the acid, is thought by some to exert a drying influence. Oil cannot be tested for acidity by the direct application of litmus; but filtered water used for washing the oil will redden litmus-paper if any acid was present in the oil. Crisp thinks that no very fatty oils (neat'sfoot, lard) will repay the trouble of washing and refining; and he is of opinion that all oils refined by heat, by evaporation, by alcohol, or by any quick method, though looking clear and bright, have their lasting properties quite destroyed. He declares it is only by a slow process of abstracting the deposits from the oil at 30° to 32° F. (– 1° to 0° C.) that a reliable oil can be obtained suitable for watchmakers. Vaseline may be used with great advantage in the priming up of fusees; a small quantity may also be applied to the collet. Oils for chronometers or watches ought (1) to be chemically pure, (2) not to gum or clog, (3) not to evaporate, (4) not to freeze. Before refining, sperm-oil gums; olive-oil is acid, and discolours steel and brass, which acidity is much reduced or annihilated by the washing process; neat'sfoot-oil is very hard to get genuine. Rarely can the oil be depended upon that is offered

in the market; besides, neat'sfoot is a very tender oil, and requires to be filtered at a very low temperature to get rid of the stearine. As an instance of this, a gallon obtained perfectly genuine was quite solid at a temperature of 50° F. (10° C.). Upon putting this gallon into a bag, about 1 qt. filtered through the bag at a temperature of 32° F. (0° C.), which is the only portion suitable for watchmakers, and this portion requires washing and again filtering to get rid of its acidity. This is also about the proportion that can be obtained from olive and sperm oils, yielding about ¼, or 1 qt. per gallon, under the same conditions of obtaining oil under the cold process.

(*b*) Olive-oil containing a strip of clean lead is exposed to the sun in a white glass vessel till all deposit ceases, and the supernatant oil is limpid and colourless.

(*c*) Obtain some pure gallipoli oil and freeze it (by the use of ice or freezing mixture) to precipitate impurities. Leave it so a day or two. Let it then thaw out by the heat of a room, then pour off the clear portion. Add to this $\frac{1}{50}$ part (2 per cent.) of neat'sfoot-oil (not less than two months old). This is a good lubricant for the purpose.

(*d*) Take any pure and light oil and put it in a retort with eight times its weight of absolute alcohol. Boil for ten minutes, pour off and allow to cool. Now evaporate until it is reduced to one-fifth its original volume, and it is ready for use. Keep in well-stoppered bottles. It is suited for the finest work.

(2) Oleine for lubricating fine mechanism is prepared by agitating almond- or olive-oil with 7 or 8 times its weight of strong alcohol (sp. gr. 0·798) at nearly boiling-point; the solution is allowed to cool, and the clear fluid is decanted, filtered, and heated to drive off the alcohol. It may further be exposed to a low temperature to deposit any remaining stearine.

(3) *Sewing-Machine.*—(*a*) Best. 9 oz. pale oil of almonds, 3 oz. rectified benzoline, 1 oz. foreign oil of lavender. Mix and filter.

(*b*) Common.—3 oz. petroleum, 9 oz. pale nut-oil, 40 to 50 drops essential oil of almonds. Mix and filter.

(*c*) The writer was given a simple recipe of 2 parts sperm-oil and 1 part petroleum. He made a quart of this for domestic use, and it answered excellently. Through not having a great use for it, the quantity made was not finished for about twelve years, and at the expiration of this time the oil was as good as at first though a little darker in colour.

(4) *Cycle-oil.*—This is commonly made up of sperm-oil and vaseline, three of the former to one of the latter by weight. A greater quantity of vaseline could be used and some mineral-oil as a thinning agent.

(5) *Cycle-chain Lubricant.*—(*a*) Melt some tallow (Russian for preference), then stir in powdered plumbago (graphite or black-lead) until it is thick enough that it will set solid when cold. While fluid pour it into moulds.

(*b*) The foregoing recipe applies to blocks of hard lubricant that is rubbed on the chain. If the chain can be soaked and stirred about in the fluid mixture, it is much better.

(*c*) Mix plumbago and vaseline to a stiff consistency. This does not set, but is applied with a brush.

LUMINOUS PAINTS AND BODIES.

THE luminosity of minerals has an obvious practical value in the case of such substances as can be conveniently applied in the form of a paint to surfaces which are alternately exposed to light and darkness, such exposed surfaces emitting at one time the light which they have absorbed at another. Familiar illustrations are street plates, buoys, and interiors of railway carriages having to traverse many tunnels. The light absorbed may be either daylight or powerful artificial light. With this object, several compositions are prepared under the generic name of luminous paints. They are chiefly as follows:—

(1) **Coloured Luminous Paints.** In making luminous paints a vehicle that is used with advantage is a varnish that has no trace of lead in its composition, for lead has a prejudicial effect on the luminous ingredient. This varnish is made of Kauri or Zanzibar copal, 6 parts, oil of turpentine, 24 parts, the copal being made into a molten state and then dissolved in the turpentine. When this solution is made, it is filtered and mixed with 10 parts pure linseed-oil (without lead in it), the oil being well heated and allowed to cool before the copal solution is mixed with it. This completes the varnish. In dealing with the dry materials, these should be ground before mixing. A paint-mill is suited for this, but the rolls or grinding surface should not be iron if possible, as minute particles of iron are carried in the ingredients with bad effect. The chief dry ingredient is luminous calcium sulphide. This is made by mixing 50 parts of lime with 20 parts of flowers of sulphur and heating together in a closed crucible until fumes cease to be evolved. The substance remaining is calcium sulphide, and requires to be powdered finely.

Red.—30 parts of the varnish described, 1 part madder lake, 3 parts of red arsenic sulphide (realgar), 4 parts powdered sulphate of barium, 15 parts luminous calcium sulphide.

Blue.—21 parts of the varnish, 3·2 parts ultramarine blue, 2·7 parts cobalt blue, 5·1 parts sulphate of barium, 23 parts luminous calcium sulphide.

Green.—12 parts of the varnish, 2 parts green oxide of chromium, 2·5 parts sulphate of barium, 8·5 parts of luminous sulphide of calcium.

Yellow.—12 parts of the varnish, 2 parts of barium chromate, 2¼ parts of barium sulphate, 8·5 parts of luminous calcium sulphide.

Orange.—92 parts of the varnish, 2 parts Indian yellow, 35 parts sulphate of barium, 3 parts madder lake, 76 parts of luminous calcium sulphide.

Violet.—21 parts of the varnish, 2·4 parts ultramarine violet, 4·5 parts cobaltous arsenate, 5·1 parts barium sulphate, 18 parts luminous calcium sulphide.

Orange-brown.—24 parts of the varnish, 4 parts of auri pigment, 5 parts barium sulphate, 17 parts luminous calcium sulphide.

White.—10 parts of the varnish, 1·5 part calcium carbonate, 3 parts white zinc sulphide, 1·5 part barium sulphate, 9 parts luminous calcium sulphide.

(2) *Balmain's.*—This consists of a phosphorescent substance introduced into ordinary paint. The phosphorescent substance employed for the purpose is a compound obtained by simply heating together a mixture of lime and sulphur, or substances containing lime and sulphur, such as alabaster, gypsum, etc., with carbon or other agent to remove a portion of the oxygen present; or by heating lime in a vapour containing sulphur. In applying this phosphorescent powder, the best results are obtained by mixing it with a colourless varnish made from mastic and turpentine; drying oils, gums, pastes, sizes, etc., may, however, also be used.

(3) *A French Compound.*—100 lb.

of a carbonate of lime and phosphate of lime produced by the calcination of sea-shells, and especially those of the genus *Tridacna* and the cuttle-fish bone, intimately mixed with 100 lb. of lime rendered chemically pure by calcination, 25 lb. of calcined sea-salt, 25 to 50 per cent. of the whole mass of sulphur, incorporated by the process of sublimation, and 3 to 7 per cent. of colouring matter in the form of powder composed of mono-sulphide of calcium, barium, strontium, uranium, magnesium, aluminium, or other mineral or substance producing the same physical appearances, i.e. which, after having been impregnated with light, becomes luminous in the dark. After having mixed these five ingredients intimately, the composition obtained is ready for use. In certain cases, and more especially for augmenting the intensity and the duration of the luminous effect of the composition, a sixth ingredient is added in the form of phosphorus reduced to powder, which is obtained from seaweed by the well-known process of calcination. As to proportion, it is found that the phosphorus contained in a quantity of seaweed, representing 25 per cent. of the weight of the composition formed by the five above-named ingredients, gives very good results.

The phosphorescent powder thus obtained and reduced into paste by the addition of a sufficient quantity of varnish, such as copal, may serve for illuminating a great number of objects, by arranging it in more or less thick coatings, or by the application of one or more coatings of the powder incorporated in the varnish, or by varnishing previously and sprinkling the dry powder upon the varnish. The amount of powder applied should not exceed the thickness of a thin sheet of cardboard.

The dry phosphorescent powders are also converted into translucent flexible sheets of unlimited length, thickness, and width, by mixing them with about 80 per cent. of their weight of ether and collodion in equal parts in a close vessel, and rolling the product into sheets with which any objects may be covered which are intended to be luminous in the dark. The powders may also be intimately mixed with stearine, paraffin, rectified glue, isinglass, liquid silex, or other transparent solid matter, in the proportion of 20 to 30 per cent. of the former with 50 to 80 per cent. of either of these substances, and this mass is then reduced into sheets of variable length, width, and thickness, according to their intended applications. A luminous glass is also manufactured by means of the powders by mixing them in glass in a fused state in the proportions of 5 to 20 per cent. of the mass of glass. After the composition has been puddled or mixed, it is converted into different articles, according to the ordinary processes; or after the manufacture of an object still warm and plastic, made of ordinary glass, it is sprinkled with the powders, which latter are then incorporated into the surface of the article by pressure exerted in the mould, or in any other suitable way.

It has been observed after various trials that the passage of an electric current through the different compositions augments their luminous properties or brilliancy to a great extent; this peculiarity is intended to be utilised in various applications too numerous to describe; but of which buoys form a good example. The current of electricity is furnished by plates of zinc and copper mounted on the buoy itself, when the latter is used at sea; but in rivers and fresh-water inlets the battery will be carried in the interior of the buoy. To secure the full effect, 10 to 20 per cent. of fine zinc, copper, or antimony dust is added to the phosphorescent powder described.

(4) Take oyster-shells and clean them with warm water; put them into the fire for ½ hour; at the end of that time take them out and let them cool. When quite cool, pound them fine, and take away any grey parts, as they are of no use. Put the powder in a crucible with alternate layers of flowers of

sulphur. Put on the lid, and cement with sand made into a stiff paste with beer. When dry, put over the fire and bake for an hour. Wait until quite cold before opening the lid. The product ought to be white. You must separate all grey parts, as they are not luminous. Make a sifter in the following manner: Take a pot, put a piece of very fine muslin very loosely across it, tie around with a string, put the powder into the top, and rake about until only the coarse powder remains; open the pot, and you will find a very small powder. Mix it into a thin paint with gum water, as two thin applications are better than one thick one. This will give paint that will remain luminous far into the night, provided it is exposed to the light during the day.

(5) Sulphides of calcium, of barium, of strontium, etc., give phosphorescent powders when duly heated. Each sulphide has a predominant colour, but the temperature to which it is heated has a modifying effect on the colour. Calcine in a covered crucible, along with powdered charcoal, sulphate of lime, sulphate of barytes, or sulphate of strontia; there is produced in each case a greyish-white powder, which, after exposure to strong light (either sunlight or magnesium light) will be phosphorescent, the colour depending on the sulphate used and the degree of heat employed.

(6) Five parts of a luminous sulphide of an alkaline earth, 10 of fluorspar, cryolite, or other similar fluoride, 1 of barium borate; powdered, mixed, made into a cream with water, painted on the glass or stone article, dried, and fired in the usual way for enamels. If the article contains an oxide of iron, lead, or other metal, it must be first glazed with ground felspar, silica, lime phosphate, or clay, to keep the sulphur of the sulphide from combining with the metal. The result is an enamelled luminous article. (Heaton and Bolas.)

(7) Boil for 1 hour 2½ oz. caustic lime, recently prepared by calcining clean white shells at a strong red heat, with 1 oz. pure sulphur (floured) and 1 qt. soft water. Set aside in a covered vessel for a few days; then pour off the liquid, collect the clear orange-coloured crystals which have deposited, and let them drain and dry on bibulous paper. Place the dried sulphide in a clean graphite crucible provided with a cover. Heat for ½ hour at a temperature just short of redness, then quickly for about 15 minutes at a white heat. Remove cover, and pack in clay until perfectly cold. A small quantity of pure calcium fluoride is added to the sulphide before heating it. It may be mixed with alcoholic copal varnish. ('Boston Jl. Chem.')

(8) *Simple Luminous Writing.*—This is effected by fixing a small piece of phosphorus on a quill and writing with this. The writing is luminous when placed in a dark room.

(9) *Luminous Ink.*—Carefully grind luminous calcium sulphide in very thin gum-water (for calcium sulphide, see (1)). The writing must be exposed to bright daylight each day, to be luminous at night.

(10) The luminous properties of minerals have received from men of science a good deal of attention, and have led in consequence to the elucidation of many interesting facts. Margraaf has ascertained that all the earthy sulphates, when calcined, exhibit this property, and that the metals, metallic ores, and agates are not phosphorescent; the former portion of the discovery had already been partly made known by a shoemaker of Bologna named Vincenzo Casceriola, the inventor of the famous Bolognian stone, which is prepared by strongly heating heavy spar (sulphate of baryta) with gum tragacanth. Most of the minerals having phosphorescent properties only exhibit them after insolation or exposure to the sun. Of these, the following are good examples: the diamond and several other precious stones; the Bolognian stone, mentioned above; Canton phosphorus, prepared from water-worn oyster-shells, calcined

with sulphur; it appears on the mass as a white coating, which is scraped off, and should be kept in stoppered bottles. Dr. Fry, in 1874, found similar properties in gypsum, marble, and chalk; and Baldwin, of Misnia, in 1677, discovered that the residue of chalk in nitric acid was similarly affected. Some even go so far as to assert that all minerals containing a fixed acid are capable of becoming phosphorescent by insolation or other means. Fused nitrate of calcium and petrifactions are also rendered luminous by this means. It is a fact worth noting that insolation effects the phosphorescence best in badly-conducting minerals.

Phosphorescence has been noticed, too, in the change from the amorphous to the crystalline state, and separation of crystals from a solution. Another source of this light, and one not often noticed, is that caused by mechanical means, either percussion or friction; the phosphorescence, however, in this case, lasts only so long as the disturbing influence is at work. Among the substances that are mentioned as affected by this agency, the most characteristic is adularia, a transparent variety of potash felspar (orthoclase) which is found in fine crystals in Cornwall, and also at St. Gothard, in the Alps. This remarkable mineral, when struck so as to split, shows at each crack a streak of light which may last some little time, and when ground in a mortar has the property of appearing to be on fire. Quartz, fluorspar, and rock-salt, also exhibit this property when pounded, but in a far less degree than adularia. In the great majority of cases, the duration of the phosphorescence in natural bodies is extremely short; but, nevertheless, Becquerel invented a most ingenious instrument, which he called a "phosphoroscope," which will measure the length of the existence of the most short-lived phosphorescent flash. An interesting and remarkable discovery was made by Beccari, of Turin, who found that a phosphorescent body gave out in many cases the light to which it had been subjected. This ingenious philosopher also discovered that snow could be rendered slightly luminous by insolation. Some specimens of zinc-blende also give out phosphorescent light, even with so slight an exciting cause as the friction of a feather; and also some kinds of marble show, when heated, a yellowish phosphorescence. (G. R. T. in 'Eng. Mech.')

(11) Some formulæ for phosphorescent paints appear in a paper by L. Vanino and J. Gans in the 'Journal für Praktische Chemie.'

The authors have tested the formulæ of a great number of writers, and state those of Lenard, Mourelo, Vanino, and Balmain to be the best. These are as follows:—

Lenard.—Strontium carbonate, 100 grm.; sulphur, 100 grm.; potass chloride, 0·5 grm.; sodium chloride, 0·5 grm.; manganous chloride, 0·4 grm. The mixture is heated for ¾ hour in the furnace.

Mourelo.—Strontium carbonate, 100 grm.; sulphur, 30 grm.; soda, 2 grm.; sodium chloride, 0·5 grm.; manganous sulphate, 0·2 grm.

Balmain.—Calcium oxide (quicklime), free from iron, 20 grm.; sulphur, 6 grm.; starch, 2 grm.; bismuth nitrate (5 per cent. alcoholic solution), 1 c.c.; potass chloride, 0·15 grm.; sodium chloride, 0·15 grm. Heated for ¾ hour.

Another excellent formula is: Calcium oxide, 20 grm.; sulphur, 6 grm.; starch, 2 grm.; potass chloride, 0·5 grm.; sodium chloride, 0·5 grm.; bismuth chloride (0·5 per cent. alcoholic solution), 1 c.c.; calcium fluoride, 3 grm. The authors find that the Heraens mercury-vapour lamp is an excellent light for exciting phosphorescence of the paints.

MACHINERY CASTINGS,

PICKLING AND CLEANING.

CASTINGS that are to be machined require to have the scale and dross removed, and while in certain cases the sand-blast is used for this purpose, the more common practice is to subject the castings to an acid "pickle."

Iron.—Iron castings are usually pickled with sulphuric acid or hydrofluoric acid, the former being most commonly used. The sulphuric acid pickling solution is usually made up of 1 part of sulphuric acid to 10 parts of water. The sulphuric acid should always be poured into the water while the latter is being stirred. The reason for this is that a chemical reaction takes place which causes the bath to become quite warm; but there is no dangerous ebullition if properly mixed. But if the water is poured upon the sulphuric acid, the latter, being much heavier than water, remains at the bottom. When an attempt is made to stir the solution, the water enters the acid in small streams, and is instantly raised to the boiling-point, generating steam, which may cause an explosion. Such an accident would be likely to throw the concentrated acid over the workman, and result in serious burns.

Sulphuric acid will not attack the sand or black oxide of iron forming the scale upon castings, but the sand and scale are porous, and the acid soaks through and attacks the iron under the scale. It finally dissolves a sufficient amount of iron under the scale to loosen the latter. When the workman sees that the scale is all loose, the castings should be removed and washed, preferably with hot water. If the castings are small it is a good practice, after washing, to immerse them in a soda solution for a short time in order to thoroughly neutralise any acid.

One great objection to the use of sulphuric acid as a pickling solution is that, if there are any soft or spongy spots in the iron, the acid will penetrate these, and it would be practically impossible to wash it out or neutralise it in the soda bath. Any acid thus entrapped in the castings will continue to eat until it is changed to sulphate of iron or green vitriol. This will tend to make the spongy or soft spots in the iron still worse, and may weaken the castings to a large extent. If the acid has been used a number of times a large portion of it is converted into green vitriol, and hence the solution will not attack the iron. In this case, it is necessary to add more acid to the bath, or else to throw away the old bath and make up a new one.

While the workman may receive quite serious burns from sulphuric acid, it is not nearly as dangerous as hydrofluoric acid. The thin hydrofluoric acid will penetrate the skin and attack the flesh and bones underneath, and may result in very serious injuries. It will also attack the finger-nails very readily; but if used with care, it makes a pickling solution which has a number of advantages over sulphuric acid.

Hydrofluoric acid is commonly sold in three grades. The first contains 30 per cent. of acid, the second 48 per cent., and the third 52 per cent., the balance of the solution being water. The 30 per cent. solution is that usually employed for pickling castings. One gallon of the 30 per cent. solution should be used to twenty to twenty-five gallons of water. If it is desired to pickle more rapidly, less water may be used, and if it is desired to get more use of the acid—that is, make it do more work—slightly more water may be used. Hydrofluoric acid does not act upon the iron to an appreciable extent, but attacks the sand and dissolves it. It also dissolves the black oxide of iron.

When castings are pickled in sulphuric acid the surface is left with a dull or black appearance. When pickled in hydrofluoric acid the surface has a much whiter and often almost silvery appearance. The surface of castings pickled with hydrofluoric acid is also

very much smoother than those pickled with sulphuric acid. For this reason hydrofluoric acid pickling is used in almost all cases in which the parts are to be polished or nickel-plated, and sulphuric acid pickling only in cases where it is desired to remove the scale so as to facilitate the machining of the castings.

When pickling with hydrofluoric acid the small casting may be put into the bath and the larger ones may have the acid poured over them just as if working with sulphuric acid. The hydrofluoric acid bath is always used cold, but should be kept above the freezing-point. The bath can be used repeatedly by adding about one-third the original quantity of acid before introducing a new lot of castings. If it is desired to keep the surface of the castings bright after they are pickled in hydrofluoric acid they should be washed with hot water immediately after coming out of the acid, and should be left in the water until they are heated through. If this is done when the castings are taken out of the water, they will dry quickly from the heat which they have absorbed from the water. If the castings are washed in cold water they will remain wet for some time, and hence will rust. A little lime is frequently added to the washing water which is used after hydrofluoric acid pickling.

When handling concentrated hydrofluoric acid the workman should always use rubber gloves. If any acid is dropped or splashed on the skin it should be washed off at once with water and dilute ammonia, and this will usually prevent any injury. The dilute hydrofluoric acid of the pickle bath will not attack the skin instantly, but the workman should never put his hands into this solution as it will attack the hands to some extent, and will result in serious sores, if he persists in handling the castings when wet with the pickling solution. The dilute sulphuric acid pickling solution will not injure the hands, if it is spilled upon them; in fact, its only effect is to make the skin coarse and rough.

Brass Castings.—For pickling brass castings, a solution is frequently made up by mixing three parts of sulphuric acid and two parts of nitric acid, and adding to each quart of the mixture about a handful of common table salt. This mixture is frequently used undiluted with water, and is to be handled with great care, as it will attack the hands badly. One advantage of this solution is that it leaves a good colour on the castings, and hence it is frequently used for this purpose.

The pickling solution used for brass castings must be kept in an earthenware crock or in a vitrified bath tub, and the bath must be large enough to dip the large castings into it. Owing to the fact that hydrofluoric acid will attack sand, it cannot be kept in a crock or jug, as it would immediately eat a hole through it, and escape. Hydrofluoric acid must be kept in a lead carboy, but the dilute acid can be kept in wooden tubs or barrels. Either dilute or concentrated hydrofluoric acid will dissolve glass very readily, and hence cannot be kept in a glass bottle. Concentrated sulphuric acid is frequently kept in iron tanks, but dilute sulphuric acid attacks iron readily, and hence it is necessary to keep dilute sulphuric acid in earthenware jugs and jars, glass bottles, or wooden tubs or vats. ('Railroad Herald.')

MALLEABLE IRON.

(a) Whatever may be the scientific definition of a malleable casting, for commercial purposes it is one made of cast iron rendered malleable by subsequent annealing. The composition of the hard casting lies between well-defined limits, however, and it is affected by so many conditions that the successful production of this class of work is one of the most difficult branches of the iron industry.

While nominally the composition of a good malleable casting is but little different from that of a car-wheel or a roll, yet the fact that it can be twisted, bent and hammered out hot or cold, and has double the tensile strength of these products, shows that the constitution of the castings is quite different. This difference in the constitution may be traced to the condition of the carbon in each. In the ordinary grey casting we may have some 3 to 3½ per cent. graphite present. In the malleable casting we have the same amount, weighed as graphite in the analysis, but radically different in its characteristics. This form of carbon, due to the annealing process has been called temper-carbon, by Prof. Ledebur, who first described it in connection with the malleable (Ger. "temper") process. I will mention one of the peculiarities of this form of carbon. If a malleable casting which on fracture shows the fine black velvet surface is heated up very high and then plunged, all this amorphous carbon is dissolved, and the fracture shows the grain of a good tool steel. The same is often seen when a piece is hammered cold, and more especially when a casting that has become warped is heated up and straightened. The grain in the latter instances will not be as good as in the first one, but it shows that to straighten a malleable casting pressure only without heat should be applied. This characteristic of the carbon is often used to palm off malleable castings as steel ones, much to the disgust of the user and producer of *bonâ fide* "malleable."

The tensile strength of the malleable casting should run between 42,000 lb. and 47,000 lb. per sq. in.; though castings showing only 35,000 lb. are quite serviceable for ordinary work. It is not advisable to run much beyond 54,000 lb. per sq. in., for the resilience is reduced, and one of the most valuable properties of the malleable casting impaired. I have made much work running up to 63,000 lb. by the plentiful addition of steel to the mixture in the open-hearth furnace. I do not, however, recommend this, as wherever such high results are wanted they can best be obtained by using the steel casting direct.

The high resilience, or resistance to shock, in "malleable" is its most useful characteristic. It is well known in railroad circles that the ordinary steel casting comes nowhere near the malleable for service conditions. Only where an exceedingly high tensile strength is required, as in the car couplers for the heavy modern trains, is the malleable casting being gradually replaced. On the other hand, car castings, formerly made of grey iron, are now specified for malleable wherever possible, in the interest of greater strength and reduced weight.

Before going into the composition of good "malleable," it is necessary to look a little into its structure. Originally cast, to be perfectly chilled —that is, with the carbon all combined, and a contraction of some ¼ in. to the foot; the annealing process serves to expel the carbon from its state of combination, depositing it between the crystals of the iron, not in the crystalline graphite of the grey iron, but as an amorphous form not unlike lampblack. At the same time an expansion equal to half of the original contraction takes place, the net result being a shrinkage allowance for the pattern identical with that for grey iron castings of similar shape and thickness.

Besides this expulsion of the carbon from its combination, there is a removal of some of it from the outer portions of the casting. This amounts to nearly all in the skin to nothing ¼ in. inward. I do not take kindly to the generally accepted theory that oxygen from the packing penetrates the casting, removing the carbon by burning it out. I have always found that when oxygen has access to the interior, through the open structure of the iron itself, this is also oxidised with the carbon, and the whole presents a sorry sight. Whether, however, carbon diffuses out or not in a good casting, I cannot say, and hope that this point will some day be taken up and settled by careful experiment.

It will be noted that, owing to the removal of varying amounts of carbon from the skin to the interior, no carbon determination of a malleable casting is of any value unless the sample is taken before the anneal, and even then it is only good for the total carbon. For an annealed piece a sample taken from the centre of the fracture with at least ⅜ in. untouched around the drill would give a fair indication of the carbon contents, but cannot claim accuracy.

In former days of charcoal iron about 4·00 per cent. carbon was the rule in malleable castings. In these days of coke irons and steel additions to reduce the carbon, this may run as low as 2·75 per cent. before trouble ensues through excessive cracking and shrinkages. With the modern demand for a high tensile strength it is well to place the lowest limit at 2·75 per cent., and the upper limit for common work would be found in the saturation point of this grade of iron, or 4·25 per cent. It is absolutely necessary that the hard casting be free from graphite: even a small amount of this indicates an open structure, with consequent ruin to the work in the anneal from penetrating oxygen. To keep the carbon in the combined state is the function of the silicon percentage arranged for in the mixture, the rate of cooling due to the cross section, the pouring temperature, sand, etc.

The sulphur content is quite important, especially just now when we are getting the sweeping of the coal mines for our fuel to a greater or less extent. The percentage should not be allowed to go over 0·05, though double this may let a casting pass muster where good work is of no special object. Once the sulphur exceeds 0·05 trouble may be expected. It is, therefore, wise to hold the pig-irons below 0·04 and to see that the fuel used is not too rich in sulphur. Manganese is seldom troublesome, as it does not often exceed 0·04 in the mixture, which means 0·10 to 0·20 in the casting. Above 0·04 in the casting it begins to give trouble in the anneal, and therefore manganese as a general proposition should be kept low. Phosphorus should not exceed 0·225, and is better kept below this.

To get the proper silicon limit for the class of castings you have to make is the trick which means either success or failure for your foundry. This will be realised from the fact that you do not know how your castings will come out until about a week after they went into the anneal. Now, suppose your mixture is wrong, and the silicon is either too high, which means "low" or rotten work, or too low in the castings, making them "high" (strangely contradictory, but nevertheless shop terms in daily use, and dating back to the times when silicon was unheard of in malleable works). This means hard-burnt white castings, stronger than the first-mentioned class, but equally undesirable. You will not know of this until a whole week's work, in all probability equally bad, has been put into the ovens, and comes out in its turn only to wander into the scrap pile. Naturally, disaster stares the inexperienced founder of malleable castings in the face all the time, and only a good laboratory will keep him out of hot water, everything else being equal. It also shows the necessity for better protection to the buyer, who cannot be supposed to

distinguish between a good and only a fair casting. In general, we may say that the thicker the casting the lower the silicon allowable in order to get a white iron in the sand. Thus, the heaviest classes of work, the silicon of the casting, should not exceed 0·45. For ordinary work 0·65 is the point to be sought for. Agricultural work may run up to 0·80, while the lightest casting may have 1·25 per cent. without danger, though it is not advisable to exceed this limit for anything.

American practice differs from the European in several respects. We have a comparatively short anneal, that is, we aim at a conversion of the carbon rather than its removal. Over there it is desired to get all carbon out, so that a wrought-iron casting, if it may be so called, may result. With much of the iron cast from crucibles, it is quite possible to make very fine grades of work, and this may account for higher prices for malleable than steel castings paid in some parts of Europe. Imagine, however, what would result if we had the crucible processes here, with our average production of some 35 tons daily in the larger plants, or some 80 in the very large ones. The common American practice is to use the reverberatory or "air" furnace, either with or without the top blast over the bridge to hasten the melting. There is always a blast introduced under the grates, unless indeed in our older works the chimney draught is exceptionally good.

About twelve years ago the open-hearth furnace was introduced into one of our largest works, and it was my good fortune to gain experience with it there. While not many malleable establishments have the open-hearth furnace—I can count them on my fingers—yet it is undoubtedly the most economical melter there is, provided several things. One is that it must be kept busy as much as possible, as only then its full economy is taken advantage of. Then, skilled workmen must be kept in charge. This does not mean the steel melter with his habit of letting the heat take care of itself, and tapping a 10-ton heat five hours after charging, whereas it should come out in two hours and a half. But it means a man who will use his muscle freely to rabble up the heat, push the pigs into the bath as quickly as they can be cared for, mix his iron well, fire sharp and quick, so that the process becomes one of melting only, rather than a refining or burning out of large quantities of silicon and carbon. When these conditions prevail, the open hearth will prove a friend indeed, and turn out a most excellent product.

Let us take fair conditions with three heats daily from a 10-ton open-hearth furnace. Using producer gas, the fuel ratio is about one of coal to six of iron. In the reverberatory furnace the fuel ratio is 1 to 4 at best, and often only 1 to 2. It is not advisable to make larger heats than 15 to 18 tons, as the time consumed in melting, and especially in pouring from the small ladles after tapping, becomes so great that the bath is seriously damaged by undue oxidation and overheating. When the time comes for continuous melting in the malleable foundry, when heat after heat is taken off as fast as the bottom can be patched up and the furnace charged again. Then will the complete economy of the open-hearth furnace be fully realised. We may then also see the tilting furnace of value to us, though a device of my own, which I am using successfully in my own interests, and which allows the tapping from three spouts at different levels, successively has the advantages of the tilting furnace for "malleable" without incurring the heavy first and running costs.

For making malleable castings, the open-hearth furnace should be pushed very hard for a time, almost sufficient to collapse it, then it should be checked before actual damage is done to crown and ports. In this way a short sharp heat is obtained, the silicon of the heat

may be calculated for a loss of 20 to 25 points, whereas from 35 upwards is the rule in other processes. Three hundred heats should be taken off before repairs of several days' duration are required, and a total of at least 1000 heats only should necessitate practically a rebuilding with but little loss other than the refractories.

In the mean time, there has been much improvement in the air furnace. Strange to say, while the quantity of metal, the composition, excepting only in the phosphorus content, of the large roll and the malleable casting is the same, the air furnace used in each industry has been developed on different lines. In making rolls we find the short, high, reverberatory chamber more on the lines of the copper furnaces, while in the malleable industry the furnace is long, very low, and contracted at the stack entrance. While formerly the hearth was practically rebuilt after each heat, at the present day several heats are taken off before a new bottom is made. The bungs, of course, always suffer, and herein the crown of an open hearth is much more easily cared for. But the poor efficiency of the fuel is an inherent difficulty which cannot be overcome, and presents new difficulties with every change of quality.

At the present time there is a general difficulty with the coal used, which means castings with an undue amount of sulphur. These castings are weak and will some day wander into the scrap pile. When the next slump comes we will be confronted with a serious condition. This high sulphur scrap will come into the market; in fact, forced upon the founder, whenever his castings can be identified. They will be hard to use by him, and from the fact of high sulphur will not be available for basic steel, as was the case formerly. There is then a neat problem, and one which will make the fortune of anyone who may discover an economical remedy, and that is the removal of sulphur from iron on a commercial scale. I present this to our experimenters, and wish them success with it.

The cupola still turns out a considerable tonnage of malleable castings, but this process will be gradually superseded by the furnace method, chiefly on account of the better grade of work turned out by the latter. There is however one interesting point connected with the cupola process, or rather with cupola iron, which we must go into more fully in connection with its bearing upon the anneal. Cupola iron requires some 200° F. more than furnace iron to anneal it properly. This is a general proposition. It seems strange that it should be so, but possibly the structure of cupola iron is so close that it requires more effort to get the crystals apart and to effect the liberation of the carbon from its state of combination. Whether this is due to the contact of the metal with the fuel as it trickles down in thin streams and drops is hard to say, but the difference certainly exists, and must be provided for in the anneal.

Naturally with a higher degree of heat the wastage of the annealing pots is more marked, and the process becomes more expensive in this regard also, for our annealing boxes must be reckoned at a dead loss, which is to be diluted, as it were, by as long a life as possible in the ovens.

In studying the annealing process we find two extremes leading to about the same results, so far as the carbon change is concerned. A short anneal at a very high heat is as effective as a comparatively long anneal at a much lower temperature. That is to say, we can anneal, or rather change the carbon in a casting, by placing it overnight in a melting furnace which has been let cool below the melting-point of the iron, or do the same thing in the annealing oven at a much lower temperature, but giving it a week's time. Of the two methods the latter is by far the preferable, as it not only permits the change in the carbon, but also gives the carbon time to get out. Then, again, the chances of burning

the castings in the anneal are obviated. The result is a good reliable casting, while in the hurry-up processes one never knows whether they are annealed at all. Sometimes they are and often they are not. Malleable founders, therefore, while experimenting for generations on short annealing lines, have come to recognise that the best all round and safe method is to arrange matters so that an oven may be regularly recharged on the same day of the succeeding week.

We may describe the annealing process by a curve which runs up quickly, remains horizontal for a short time, and then drops very gradually. That is a sharp heating up, in the shortest safe time possible, then a shutting off of the dampers and maintaining of the temperature evenly for a period of, say, two full days at least, and then a gradual cooling down to at least a black heat before dumping. Here is where mistakes are often made, annealing pots being drawn red-hot because some particular casting is wanted badly. The castings are red-hot, when the air touches them; the delicate reaction of the carbon is disturbed, and an inferior material results. I have always had softer, more malleable iron from the anneals which had the extra Sunday to become cold in the oven, and were cold when dumped on Monday morning.

An oven can be brought up to heat as quickly as may be, the fuel waste to this being alone considered. In cities where the smoke problem exists, more time is required than in the open country. For a fair-sized oven at least 36 hours are required to bring it up to heat—a pyrometer should always be used to test this—and then it should be held there.

As to the actual temperatures there is this much to say. Furnace iron of average thickness must have received over 1250° F. after coming up, until cutting off the heat, to be safely annealed. Perhaps even then some of the work must be put back for another anneal. A safer limit is 1350° F., and no more is necessary. This temperature must exist in the coldest part of the furnace, or usually at the lower part of the middle in the front row pots. As a rule, the upper space of an oven is some 200° F. higher than this, although I have succeeded in building ovens in which there was but a difference of 100° F. throughout the whole interior space, the temperatures being measured with a Le Chatelier element 20 ft. long.

Translating these temperatures, we find that 680° C. is the lowest point for successful annealing of furnace iron, while 780° C. is the safest one. For cupola iron the temperature should be about 850° C. (Dr. R. Moldenke.)

(*b*) Malleable castings are peculiarly adapted to the requirements of four great classes of work—agricultural implements, railway supplies, carriage and harness castings, and pipe fittings. Were it not for the fact that malleable cast iron is not adapted to the heavier sections, it would be a sharp competitor to the grey-casting industry.

In its manufacture the special make of iron called "malleable Bessemer," or "malleable coke iron," is the principal material used; the charcoal irons, though unequalled for value, being confined to the regions where they can compete with the cheaper coke irons. The silicon should be 0·75 to 1·50 per cent.; phosphorus under 0·200 per cent.; while sulphur should be below 0·04 per cent. if possible. A pig-iron higher in sulphur, in reality an "Off-Bessemer," while meeting the silicon specifications perfectly, should not be used except in limited quantity, and then carefully washed.

With the pig-iron, hard sprues (unannealed scrap), steel, and also malleable scrap are charged. The latter two materials are very good to add to the mixture, as they raise the strength of the casting very considerably. Care must be taken not to add too much, as this reduces the carbon to a point where fluidity and life in the melted metal is sacrificed.

"Malleable" is produced in the

cupola, the reverberatory furnace, and the open hearth. The first process, under ordinary conditions, is the cheapest. The iron made is, however, by no means the best. Test bars made of cupola iron seldom run above 40,000 lb. per sq. in. while with furnace iron there is no difficulty in getting a few thousand pounds more. The most serious objection to cupola iron is its poor behaviour under the bending test, the deflection being very slight.

In the reverberatory and in the open hearth the fuel is not in contact with the metal, and the result is much more satisfactory. The metal in these furnaces may either be caught in the ordinary hand ladles, or it is tapped into a large crane ladle and conveyed to the distributing point, and there emptied into hand ladles as required. When tapped into hand ladles, the time taken is a serious item, for the beginning and the end of the heat will be two different things. The latter iron especially will be inferior, as it was subjected to the oxidising effects of the flame much longer than the first part. As a rule, this difficulty is somewhat remedied by pouring the light work first, the heavier pieces coming later, when the silicon has been lowered too much for good light castings. With the crane ladle pour, the moulder has much less space to travel over, and this will doubtless be the coming method.

It takes a good man in the foundry, as well as in the pattern shop, to handle malleable casting questions properly. The gating should be done to avoid the shrinkage effects as much as may be, while the little tricks that can be applied make a surprising difference in the moulding loss. As a consequence, some malleable works seldom lose more than 10 per cent., while in others 20 per cent. and over is the rule.

After the castings have been tumbled they go to the annealing-room, where they are packed in mill cinder or iron ore in cast-iron boxes. These are carefully luted up, and heated up in suitably constructed ovens for the space of five or six days. It usually takes 36 to 48 hours to get the oven up to heat, the temperature ranging from 1600° to 1800° F. in the oven, the boxes having a somewhat lower temperature at the coldest point. When the fire is extinguished, the dampers are closed tight, all air excluded, and the oven allowed to cool very gradually, often but 400° F. the first day. After the castings come from the anneal, they are again tumbled to remove the burnt scale, and they are chipped and ground for shipment.

The hard casting should have its carbon practically all in the combined state, while the annealing process should convert this to the so-called temper, or annealing carbon. A well-annealed casting should not have much over 0·06 to 0·12 per cent. combined carbon remaining in it. Under-annealed castings can be readily detected by their brittleness, but it takes much experience to be sure that a casting is over-annealed. There is a material difference between the strength of an over-annealed casting and a normal one. Two bars were taken from each of five heats. One bar from each set was given the usual anneal, and the others were re-annealed. The average tensile strength of the first set was 50,520 lb. per sq. in., the average elongation being 6¾ per cent. in 6 in. The re-annealed set had an average tensile strength of 43,510 lb. per sq. in., the average elongation being 6¼ per cent. in 6 in. Over-annealing had therefore cost the metal some 7000 lb. of its strength.

The fact that malleable castings are little understood may account for the limited way in which they are specified. While some railroads specify the mixture, composition and strength of grey castings, they do little in the way of the malleable. One railroad for which I made castings, called for 40,000lb. per sq. in., and an elongation of 5 per cent. in 2 in. for sections ½ in. and under, and 30,000 lb. per sq. in., with a corresponding elongation of 2½

per cent. for sections $\frac{3}{8}$ in. to 1 in. thick.

To show to what degree some foundries are making iron for these demands, I took test-pieces from some of their castings. The tensile strength and elongation in 6 in. of these pieces was as follows :—

	Lb. per sq. in.		Per cent. elongation.
No. 1	35,030	and	4·7
„ 2	34,410	„	3·3
„ 3	37,840	„	4·2
„ 4	45,550	„	4·0

It was also rather odd that the thicker pieces showed the better iron, for usually founders err in the pouring of heavy castings with mixtures intended for light work.

"Malleable" can be made up to 60,000 lb. per sq. in., though this is not advisable, as the shock-resisting qualities are sacrificed. Yet, as specifications become more severe, the general quality of this class of castings will be improved until we get a more reliable article, and which can better resist the encroachments of the steel casting. ('Journal of the American Foundrymen's Association.')

(c) The term malleable-iron castings means an iron that has been cast into any desired shape, and then malleableised by removing the carbon by a process of annealing, which consists in burning off the whole or a part of the carbon combined with the iron from which the castings were made. In the manufacture of malleable iron castings, the first object is to get the proper kind of pig-iron, for all iron is not suitable for making malleable iron by the process of annealing. From the states in which carbon exists in cast-iron, this has been classified into 3 principal subdivisions. The first is "grey" metal or "No. 1 foundry pig," in which the carbon is not combined with the iron, but is in the graphitic state, and may be seen in large flakes, when the iron is broken. These flakes are sometimes called "tissue" and "black-lead." The second division is "mottled" cast iron. In this the carbon is partly combined with iron and partly in the graphitic state, which gives the iron a spotted or mottled appearance. The third division is "white" cast iron. In this the carbon is combined with the iron, and is unseen.

Grey or No. 1 foundry iron is best for ordinary foundry castings, because it contains the most carbon, and is softer and will remain fluid longer than either the mottled or white irons, yet it is not best for malleable castings, for the carbon in it is not combined with the iron, and in converting the castings into malleable iron, the carbon is extracted from the iron without melting the castings, and if this class of iron is used the castings will be full of small holes after they have been malleableised, and will not have the required strength.

The iron that will make the best malleable castings is white cast iron, for in this the carbon is completely combined with the iron, and when it is abstracted from it by the annealing process, it leaves a perfectly sound and smooth casting. But in using this iron for malleable castings another trouble arises. The iron contains so little carbon that it will not retain its fluidity long enough to be run into light castings, and almost all malleable castings are very light; so that this class of iron cannot be used.

As the grey or No. 1 foundry iron contains too much carbon, and the white iron too little carbon, the best iron for malleable castings must be the mottled iron which is between the two extremes. This iron is always used for malleable iron castings, and none but the very best brands of cold-blast charcoal mottled iron will produce a good malleable casting.

Iron for malleable castings may be melted in a cupola or in either of the reverberatory furnaces. But the iron melted in a reverberatory furnace always produces by far the best castings; for the iron is not melted in contact with the fuel, as in the cupola,

and it is not deteriorated by the impurities contained in the fuel. There is also the advantage that, should the iron contain too much carbon, part of it may be removed by the oxidising action of the flame.

As most malleable castings are very small they are generally moulded in snap-flasks, with greensand, from metallic patterns or match-plates. The castings, before they are annealed, are as hard and brittle as glass, and they must be handled with care to prevent breaking. These castings are put into a tumbler or rattle barrel, where they are cleaned of all adhering sand, and become polished by mutual friction; to anneal them properly it is very essential that they should be thoroughly cleaned. The cleaned castings intended for conversion into malleable iron, are next packed into iron boxes with alternate layers of fine iron scales from rolling mills. The boxes are then closed at the top by a mixture of sand and clay, and all the cracks are carefully luted, to prevent the admission of air. The boxes are next put into the annealing oven, where they are subjected to a white heat, not sufficiently hot, however, to melt the boxes. They are kept at this heat for a week or more, and then allowed to cool off gradually. After the castings have been properly annealed, they are covered with a film of oxide of different colours, and resemble in appearance that kind of Champlain iron ore called peacock ore. These various colours of the oxide are a sign of good malleables. This adherent oxide is removed from the casting by another passage through the rattle barrel, and the process of malleable iron making is finished.

Powdered iron ore is sometimes used in place of iron scales, but it is not so good, for it contains more or less silica and earth, which at the temperature of the annealing oven, will fuse and form a slag or cinder, and prevent the oxidising action on the castings. For this reason, scales are to be preferred, and care should always be taken to keep them as free from earthy matter as possible. In every "heat" or annealing operation, the scales part with some of their oxidising properties, and before they are again used they must be pickled and reoxidised. This is done by wetting them with a solution of sal-ammoniac and water, and mixing and drying them until they are thoroughly rusted, when they are again ready for use. The annealing boxes were formerly made of soft iron, but at present they are mostly made of hard iron—the same as the castings are made of. The hard-iron boxes become annealed the same as the castings, and will last longer than the soft-iron boxes. These boxes are generally made about 20 in. long by 14 in. wide and 14 in. deep. They are set one on top of another in the annealing oven, but never more than two high. The lower one has a bottom cast in it, but the top one has no bottom, and is merely a frame set on the lower box. These boxes only last a few heats, and the small boxes are said to last longer than the larger ones.

There are several different kinds of annealing ovens in use, and some very important improvements have been made in their construction in the last few years. The best in use at the present time is one with a fire on each side of it, and so arranged that the flame from the fuel does not enter the oven or strike the boxes. This oven is not allowed to cool off, but is kept hot all the time, and at one end there is a door through which the annealing boxes are removed while at a white heat, and are replaced by cold ones. The door is then closed, and the boxes heated to the required degree. This kind of oven is most economical in use, for it requires less fuel than any other, and is not injured by expansion and contraction in cooling and reheating, as the other ovens are. When annealing the castings in the oven, care should be taken to not have the temperature of the oven too high, nor the heat too prolonged, or the castings may be burned and hardened after they have been softened. After the castings have been thoroughly decarbonised by an-

nealing in the oven, they are virtually a commercially pure iron, and are the same as wrought-iron without fibre, and fibre may be imparted to them by rolling or hammering. Yet these castings without fibre are sometimes equal to the best wrought iron for strength, and may be bent double when cold without breaking them. ('Iron Age.')

(*d*) The process is conveniently applicable only to small castings, although pieces of considerable size are sometimes thus treated. Handles, latches, and other similar articles, cheap harness mountings, ploughshares, iron handles for tools, wheels and pinions, and many small parts of machinery are made of malleable cast iron, or as steel castings. For such pieces, charcoal cast iron of the best quality should be selected, in order to ensure the greatest possible purity in the malleable product. The castings are made in the usual way, and are then embedded in oxide of iron—in the form, usually, of hematite ore—or in peroxide of manganese, and exposed to the temperature of a full red heat for a sufficient length of time to ensure the nearly complete removal of the carbon. The process with large pieces requires many days. If the iron is carefully selected, and the decarbonisation is thoroughly performed, the castings are nearly as strong and sometimes hardly less malleable than fairly good wrought iron, and they can be worked like that metal. They will not weld, however. The pig-iron should be very free from sulphur and phosphorus. The best makers have usually melted the metal in crucibles having a capacity of 50 to 75 lb., keeping it carefully covered to exclude cinder and other foreign matter. The furnace is similar to that of the brass foundry, 2 to 2½ ft. square, and the fire is kept up by natural draught. The temperature is determined with sufficient accuracy for the practical purposes of the iron-founder by withdrawing a portion on an iron bar. If hot enough, the drop burns on exposure to the air. If right, the metal is poured quickly. The "cementation," or decarbonisation, is conducted in cast-iron boxes, in which the articles, if small, are packed in alternate layers of the decarbonising material. As a maximum, about 800 or 1000 lb. of castings are treated at once. The largest pieces require the longest time. The fire is quickly raised to the maximum temperature, but at the close of the process the furnace is cooled very slowly. The operation requires 3 to 5 days with ordinary small castings, and may take 2 weeks for large pieces. This process was invented in 1759. Decarbonisation is often performed, in the production of steel castings, by a process of dilution accompanied with possibly some "dissociation." By the preceding method the carbon takes oxygen from the surrounding oxides, and passes off as carbon monoxide (carbonic oxide); in the process now referred to the carbon of the cast iron is shared between the latter and the wrought iron mixed with it in the melting-pot, and a small portion may possibly pass off oxidised. The latter method has been practised to some extent for a century. Selected cast iron and good wrought iron are melted down together in a crucible, and cast in moulds like cast iron. The metal thus produced contains a percentage of carbon, which is determined by the proportions of cast and wrought iron in the mixture. The amount is so small, frequently, that the castings can be forged like wrought iron.

(*e*) The 'Chemische Centralblatt' describes the following method practised in Germany for the preparation of malleable cast iron: It consists of two operations: (1) pouring the cast iron into moulds, and (2) removing part of the carbon contained in the castings. This is conducted in so-called "temporary" furnaces, wherein the castings are brought into contact with substances containing oxygen and heated to redness. The result is the formation of a very tough material, poor in carbon. The castings, contained in cast-iron vessels, are placed on a layer

of oxidising substances, and the intervening spaces are filled up with the latter. Oxide of zinc, hammer scale, brown and red iron ores, are used for this purpose—mostly the latter. The operation lasts 24 to 36 hours, and depends on the dimensions of the iron to be tempered and the degree of tempering. With regard to the latter, the limits are within a wide range, as, with a correct formula for mixing, it is possible to absorb the whole of the carbon. It is best to use iron free from manganese and containing amorphous carbon—that is, white pig-iron. The tempered iron forms an excellent material, and compares favourably with malleable iron as to firmness. It can be worked and polished with file and chisel, or forged and welded at a moderate red heat.

MANURES AND THEIR USES.

THERE are five substances which act as manures, and all the host of fertilisers on the market derive their value from the fact that they contain one or more of these bodies. The five are: nitrogen compounds, phosphates, potash compounds, lime, and organic matter. The first three benefit the plant alone, the other two also improve the texture of the soil.

Nitrogenous Manures.—The general effect of nitrogenous manures is to promote vegetative growth and leaf production; they are, therefore, of special value on plants like cabbage, spinach, and grass, where much leaf development is wanted, and for herbaceous plants where vigorous growth is necessary. Not only do they promote leaf production in good "growing" weather, but they do so at other times as well, so that when growth has been brought to a standstill by a cold spell, it may be started again by the addition of a suitable nitrogenous manure. Indeed, the inhibiting effect of low temperatures on assimilation and growth seems to be considerably modified by the addition of nitrogenous foodstuff.

Of all nitrogenous manures the quickest to act is nitrate of soda; it is, therefore, the most valuable in an emergency. Applied at the rate of 1 lb. to the rod, it is very useful when young plants are being kept back by cold weather, or showing the yellowing of the leaf characteristic of a bad condition generally. The writer has used it with advantage on young peas checked by the cold and suffering meanwhile from the attack of slugs; it is also beneficial to young carnations, the growth of which may have been similarly retarded. Similarly, a poor lawn may be improved by nitrate of soda; so long as the grass roots are still alive, it causes growth to start earlier and to cover up the bare places,

In general, whenever an early start is wanted, either to secure greater growth or to enable the plant to grow away from some pest, a small dressing of nitrate of soda at the rate indicated above may be expected to prove beneficial. Another effect of nitrate of soda is to improve the colour of the plant. Cabbages may be greatly improved in appearance by applying two small dressings, one about five weeks, the other about two weeks, before they are to be cut; they thus get a brighter, fresher colour, than they would otherwise have had. A similar improvement is effected in spinach.

Care is necessary in applying nitrate of soda. Like other saline manures, it should not be put on to dry soil, nor should the salt get on to the young foliage. The most satisfactory way is to dissolve the pound in about 2 gal. of water, and to pour this solution on to the soil.

Though not quite as useful as nitrate in an emergency, sulphate of ammonia is practically equal to it for all ordinary purposes, and for some special purposes it is considered superior. Thus it is found to be better for potatoes; it increases the yield without injuriously affecting the quality. There is a common belief among barley growers, which is probably well founded, that their crop is affected in the same way; the yield increases, but the quality does not deteriorate. Its general effect of promoting vegetative growth is sometimes of advantage to the exhibitor who wishes to keep his plants growing a little longer. Chrysanthemums and other plants, which promised to be over a few days before the show, have been kept going for the necessary time by applying a small amount dissolved in water.

As a dressing for the kitchen garden and herbaceous border, 1 lb. to the rod, applied with the precautions given above, is probably sufficient; this quantity contains somewhat more nitrogen than does a pound of nitrate of soda.

Phosphates.—The second manurial constituent is phosphoric acid, invariably, however, combined as phosphate, and nearly always as calcium phosphate. Four important fertilisers owe their value to this body—superphosphate, basic slag, bone manures, and ordinary Peruvian guano. Phosphates tend to produce a fibrous root development, and are very useful for plants like turnips and potatoes, which depend to a large extent on a proper development of fine roots near the surface. Probably, most herbaceous plants would be found for this reason to benefit by phosphatic manures. Another valuable function is that they promote the ripening processes, so that a crop well manured with phosphates will finish sooner and ripen better than another receiving none. This is often strikingly illustrated in agricultural practice. Wheat, in the northern parts of England, dressed with phosphates, has been observed to ripen 10 days or more earlier than other wheat in the neighbourhood which had had no such dressing. On the Rothamsted plots the barley manured with phosphates takes on a bright golden colour, whilst the control plots are still green. Garden crops wanted to ripen early should, therefore, always be supplied with phosphates; to mention only two instances, both tomatoes and early peas have been found to benefit considerably. Flower production also seems to be promoted by phosphates, and we find the manurial recipes favoured by successful exhibitors of tulips, of roses, and of chrysanthemums. All agree in including phosphates.

On grass land they have the effect of encouraging clover, so that a lawn which originally was almost entirely grass may have its character considerably altered by one or two phosphatic dressings. This has long been known; it was observed in Cheshire a century ago, and was one of the reasons why bone manures became so exceedingly popular on pasture land; in fact, some of the less educated farmers used to

allege that the clover sprang from the bones! Of course, clover is not always wanted on a lawn, but wherever it is desired, phosphatic manure will help to encourage it. On the other hand, nitrogenous manures—nitrate of soda and sulphate of ammonia—favour the grasses, so that the clovers tend to become crowded out. By taking advantage of these two facts, the gardener can generally control the proportions of grass and of clover on his lawns, though, of course, sufficient time must be allowed for the crowding-out process.

Of the three phosphatic manures, superphosphate is the quickest to act, and the one most generally useful in spring and early summer; it should be applied at the rate of about 3 lb. to the rod, all lumps to be previously broken down, so that the distribution may be fairly uniform. It may be put straight on to the soil, but should not touch the young foliage. On heavy clay land that tends to be cold, basic slag at 5 lb. to the rod is better; by preference this should go on in autumn, but it can still be applied now. Whenever during the course of the year trenching is being done in gardens where the subsoil is clay, it is always an advantage to dig into the bottom spit about 10 lb. of basic slag to the rod.

Ordinary Peruvian guano at the rate of 5 or 6 lb. to the rod is an admirable fertiliser when applied in autumn, but at this period of the year is less useful than superphosphate. Probably most gardens would benefit by the application of phosphates where these do not already enter into the scheme of manuring. Dung, the staple dressing of the horticulturist, contains an insufficient quantity, and it is usually advantageous to add a little more.

Potash Compound. — Coming now to potash, this serves several important functions, but it is less frequently necessary as a special manure, since dung contains a fair amount, and a good dressing of dung often supplies all that is needed. There are, however, certain cases where more is wanted. In some way, not yet understood, potash helps the plant to make the food it stores up for the next generation. For instance, it increases the store of sugar in the sugar beet and mangold, and it increases the starch in the potato and the grain of wheat; it is, therefore, regularly applied to these crops. Another characteristic effect is that it prolongs the life of the plant. The fruit-trees on the potash plots of the Wye College experimental fruit garden keep their leaves longer than the others, and a similar lengthening of life also appears to take place on some of the Rothamsted potash plots. This, perhaps, accounts for the great value of potash manures on thin, chalky, or sandy soils, where the plant tends to ripen and finish off rather too soon to admit of maximum crops. Further, potash checks rank growth, and is useful in correcting an excessive autumn dressing of dung. This is clearly demonstrated on the Rothamsted mangold plots; where large amounts of nitrogenous manure without potash are applied, the growth is exceedingly rank, and the plants are liable to disease, but where potash is added the plants are healthy, and show an increased yield. Without potash the extra nitrogenous manure is worse than wasted; with potash it exerts its full effect. Potash is always worth trying in a garden, where the rankness of the foliage and the bad colour of the flowers indicate a disproportionately large amount of nitrogen in the soil. In fact, whenever colour of flowers or fruit needs improving, potash may be useful. Potash manuring has also been found to benefit bush fruit; its effect on grass land is often to encourage clover.

Several potash fertilisers are obtainable, but perhaps the most generally useful is the sulphate, which may be used at the rate of 3 or 4 lb. to the rod. The muriate may also be used, but there was, and to an extent still is, a prejudice against it on ac-

count of a supposed bad effect on the quality of potatoes; the case is not definitely proved, but most gardeners would probably prefer the sulphate, with its clean record. Kainit may be more suitable where the garden is run for profit, but it should go on only in autumn or early spring.

Organic Matters.— Lime and organic matter are of equal importance with the manures mentioned above, and each produces a characteristic effect shown by nothing else, but they also should be applied in the autumn.

As a general dressing for the kitchen garden or herbaceous border, a mixture of 1 lb. of nitrate or sulphate of ammonia, 3 lb. of superphosphate, and 3 lb. of sulphate of potash may be tried. But without doubt the great advantage of artificial manures is that the gardener who has made himself acquainted with their effects can use the particular manure or manures necessary to obtain just those results he wants. ('Gardener's Chronicle.')

Mixing Manures.—A word of caution may be given as regards the mixing of artificials. Probably it is now universally known that sulphate of ammonia must not be mixed with any manure holding free lime, notably basic slag, and precipitated phosphate. The immediate result of making such a mixture is the liberation of free ammonia, whose presence in the air can at once be detected by its pungent odour. If it is desired to apply sulphate of ammonia with one of these substances to any particular area of ground, the phosphate should be put on a month or more before the other substance. Sulphate of ammonia may, however, be mixed with the other ordinary manures, such as superphosphate, dissolved bones, bone-meal, kainit, sulphate and muriate of potash, and nitrate of soda. Nitrate of soda should not be mixed with superphosphate, dissolved bones, or dissolved guano. Not only does such a mixture result in the loss of more or less nitrogen, but the mass is apt to become sticky and difficult to sow. Superphosphate and dissolved bones should not be mixed with basic slag or precipitated phosphate, as this results in the soluble phosphate of the super or dissolved bones becoming insoluble. Potash manures (kainit and sulphate and muriate of potash) should not be mixed for more than a few hours with any "dissolved" manure (e.g. superphosphate and dissolved bones), not because anything is lost, but simply because the mass becomes smeary and unsowable. Generally speaking, the sooner a mixture of manures is sown after it is made, the better. Some mixtures, as has been indicated, get smeary, others get lumpy, while others, like basic slag and kainit, may actually become a hard, solid, stone-like mass. ('Leaflet No. 80 of the Board of Agriculture and Fisheries.')

MARBLE WORKING AND CLEANSING.

(*See also* MOSAIC-WORK, POLISHING, CLEANSING, SAND-BLAST ETCHING, ETC.)

Cutting and Shaping.—Marbles are generally cut up in the same direction in which they are quarried; this is known as sawing with the grain. Sometimes it is necessary to cut them against the grain, which renders them more difficult to work. Some marbles can only be sawn in the direction in which they are cut up. The marble worker is often obliged to rough-hew and work without the help of the saw, casings, columns, and other articles with curved outlines; sometimes, but rarely, he re-works with the chisel badly executed sawings; he then squares each piece with the saw or chisel to the required dimensions, and finally mounts the marble upon its stone core, and sets up the work in its place. The working of mouldings takes much time and trouble. The first operation is to saw the arris, then to work with a notched chisel, making several successive groovings, on account of the contour and expansion, in which but very small pieces of the material are taken, for fear of splintering it; finish with small common chisels, which should be sharp and well tempered. Cylindrical pieces, such as round pedestals, columns, urns, and vases, are worked with a chisel, and then if portable, finished on a turning lathe. When it is impossible to place the pieces in a lathe, they are thickly grooved, bolstered with the puncheon, and the desired contours obtained by means of thick panels; they are then worked with a small chisel, which removes the dust, and thus prepares the marble for polishing.

Polishing.—(*a*) Polishing includes five operations. Smoothing the roughness left by the burin is done by rubbing the marble with a piece of moist sandstone for mouldings. Either wooden or iron mullers are used, crushed and wet sandstone, or sand, more or less fine, according to the degree of polish required, being thrown under them. The second process is continued rubbing with pieces of pottery without enamel, which have only been baked once, also wet. If a brilliant polish is desired, Gothland stone instead of pottery is used, and potters' clay or fuller's earth is placed beneath the muller. This operation is performed upon granites and porphyry with emery and a lead muller, the upper part of which is encrusted with the mixture until reduced by friction to clay or an impalpable powder. As the polish depends almost entirely on these two operations, care must be taken that they are performed with a regular and steady movement. When the marble has received the first polish, the flaws, cavities, and soft spots are sought out and filled with mastic of a suitable colour. This mastic is usually composed of a mixture of yellow wax, rosin, and Burgundy pitch, mixed with a little sulphur and plaster passed through a fine sieve, which gives it the consistency of a thick paste. To colour this paste to a tone analogous to the ground tints or natural cement of the material upon which it is placed, lampblack and rouge, with a little of the prevailing colour of the material, are added. For green or red marbles, this mastic is sometimes made of gum lac, mixed with Spanish sealing-wax of the colour of the marble; it is applied hot with pincers, and these parts are polished with the rest. Sometimes crushed fragments of the marble worked are introduced into this cement; but for fine marbles, the same colours are employed which are used in painting, and which will produce the same tone as the ground; the gum lac is added to give it body and brilliancy. The third operation of polishing consists in rubbing it again with a hard pumice under which water is constantly poured unmixed with sand. For the fourth process, called softening the

ground, lead filings are mixed with the emery mud produced by the polishing of mirrors or the working of precious stones, and the marble is rubbed with a compact linen cushion, well saturated with this mixture; rouge is also used for this polish. For some outside works, and for hearths and paving tiles, marble workers confine themselves to this polish. When the marbles have holes or grains, a lead muller is substituted for the linen cushion. In order to give a perfect brilliancy to the polish, the gloss is applied. Well wash the prepared surfaces, and leave them until perfectly dry; then take a linen cushion, moistened only with water, and a little powder of calcined tin of the first quality. After rubbing with this for some time, take another cushion of dry rags, rub with it lightly, brush away any foreign substance which might scratch the marble, and a perfect polish will be obtained. A little alum mixed with the water used penetrates the pores of the marble, and more speedily gives it a polish. This polish spots very easily, and is soon tarnished and destroyed by dampness. It is necessary, when purchasing articles of polished marble, to subject them to the test of water; if there is too much alum, the marble absorbs the water, and a whitish spot is left.

(*b*) If the piece to be polished is a plane surface, it is first rubbed by means of another piece of marble, or hard stone, with the intervention of two sorts of sand and water; first with the finest river or drift sand, and then with common house or white sand, which latter leaves the surface sufficiently smooth for its subjection to the process of gritting. Three sorts of grit stone are employed; first, Newcastle grit; second, a fine grit brought from the neighbourhood of Leeds; and lastly, a still finer, called snake grit, procured at Ayr, in Scotland. These are rubbed successively on the surface with water alone; by these means the surface is gradually reduced to that closeness of texture, fitting it for the process of glazing, which is performed by means of a wooden block having a thick piece of woollen stuff wound tightly round it; the interstices of the fibres of this are filled with prepared putty powder, or peroxide of tin, and moistened with water; this being laid on the marble and loaded, it is drawn up and down the marble by means of a handle, being occasionally wetted, until the desired gloss is produced. The polishing of mouldings is done with the same materials, but with rubbers varied in shape according to that of the moulding. The block is not used in this case; in its stead a piece of linen cloth, folded to make a handful; this also contains the putty and water. Sand rubbers employed to polish a slab of large dimensions should never exceed $\frac{1}{3}$ of its length, nor $\frac{1}{2}$ of its width; but if the piece of marble is small, it may be sanded itself on a larger piece of stone. The grit rubbers are never so large that they may not be easily held in one hand; the largest block is about 14 in. in length and $4\frac{1}{2}$ in. in breadth.

Mounting.—Marble workers mount and fasten their works upon plaster mixed with a third part of dust, as pure plaster repels the marble, and causes it to swell out and burst. These are joined together by cramps and gudgeons of iron and copper, which should be carefully covered, in order that the oxides may not spot the casings. Marble chimney-pieces should be lined with lias stone or plaster.

Selecting.—Examine each piece, note its beauties, and endeavour to hide its defects before cutting or working it. When fine pieces are found, endeavour to cut them into two or three parts, in order to multiply them, cutting them in such a manner that these happy accidents may be reproduced according to taste.

Veneering. *On wood.*—Veneering upon wood is preferable, in every respect, to that on stone. For this purpose, as marble particularly the black, would break by heating it in the usual manner, place the slabs of

marble in a caldron, tightly closed, in which let them boil. Then take them from the caldron, and after this preliminary operation, subject the marble to the heat of the fire to receive a mastic of tar. The wood having been prepared in a similar manner, press the marble, coated with the mastic, upon the wood, and a perfect cohesion is effected. The cases of ornamental clocks are hollow, for the movement of the pendulum and other works. This hollowing cannot be effected on stone without detriment to its solidity. When wood is used, a frame is made of it, upon the exterior parts of which marble is to be veneered. The mixture of glue with tar is found an improvement in effecting this veneering.

Veneering on Metals.—As these possess a smooth surface, the substance which should fasten them to the marble cannot incorporate itself with them intimately enough to join both, and render them inseparable. It is therefore necessary to interpose between the metal and the marble a third body which should force them to perfectly adhere; this is effected by the use of sand-paper.

Veneering on Zinc.—Take a plate of zinc of about $\frac{1}{10}$ in. thick; make a frame o th s of the form of whatever article may be wished; upon this form glue sand-paper, leaving the rough side outermost, and upon this rough side apply the marble, having first prepared it by heating in a water-bath, and placing between the marble and the sand-paper a coating of mastic of tar. By this means, so perfect an adhesion between the marble and the zinc is effected, that the marble could be more easily broken than removed. The application of marble upon zinc can also be effected by grooving the metal in every direction with strokes of the file, but the sand-paper produces the best results. Zinc is preferred to other metals, because it possesses resistance and cheapness, and causes no other expense in the manufacture than that of cutting up to form the model. Tin does not possess the same resistance or cheapness; sheet iron is dearer; cast iron is too heavy; copper is expensive; by the application of marble upon zinc, articles can be manufactured at the same price as those veneered upon wood. In fastening marble to the metallic plating, the tar which is used in the application of marble to stone will not be sufficient. The parts must first be heated in a water-bath or over a furnace prepared for this purpose, and then, by a sieve, sprinkled with one of the following mordants: Crushed glass, grains of emery of all sizes, copper filings, castings of any metal, finely rasped lead; or any kind of powdered stone, such as sandstone, marble, granite or pumice, and rubber can also be used. When the sheets of metal and of marble have received sufficient mordant, join with a coating of tar, which fastens them strongly together. Any web of linen or cotton can be placed between the marble and the metal; this web being covered with grainy substances, stuck on by glue.

Veneering on Boxes.—The marble is first sawn to thickness and form required for the dressing case or box to which it is to be applied. The wood, usually white wood, oak or fir, is cut a little smaller than the marble which is to cover it. This wood is lined with a shaving of beechwood to prevent warping. This lining is only placed on the side which is to receive the marble; each piece of marble is then applied to the corresponding piece of wood, and stuck on by glue or other mastic. When the marble has been applied the opposite side of the wood is thinly lined with rosewood or mahogany, so that this lining forms the inside of the box which is thus prepared for receiving the necessary divisions. The four parts are then dovetailed together, and the top and bottom parts are fastened flatwise on the four sides with glue or mastic. The box being finished, the outside is pumiced and polished, and any applications of gilding can be made.

Sculpture of Marble by Acids.—Prepare a varnish by pulverising Spanish sealing-wax, and dissolving it in spirits of wine. Trace on the white marble, with a crayon, the design which is to be in relief and cover this delicately with a brush dipped in the varnish; in about 2 hours the varnish will be dry. Prepare a solvent of equal parts of spirits of wine, hydrochloric acid, and distilled vinegar; pour this solution upon the marble and it will dissolve those parts which are not covered by the varnish. When the acid has ceased to ferment, and, consequently, will no longer dissolve the marble, pour on some fresh, which continue until the ground is sufficiently grooved. When there are delicate lines in the design which should not be grooved so deeply, they should at first be covered with varnish to prevent the action of the acids upon them; then when the reliefs have been made, the marble should be well washed and the varnish removed from the delicate lines with the point of a pin; then pour on new acid, which will groove it as deeply as desired, care being taken to remove it at the proper time. When the acid has acted upon the marble, it corrodes beneath the varnish and enlarges the lines in proportion to its depth; therefore draw the lines in relief a little larger than it is desired to leave them. When the work is completed remove the varnish with spirits of wine, and, as the grounds will be very difficult to polish, they may be dotted with ordinary colours, diluted with the varnish of gum lac. The marble being thus grooved, the cavities may be filled in with inlaid work of gold, silver, tin, sealing wax, sulphur, or pearl shell reduced to powder. These designs can be made either in moulding or in relief, without changing or injuring the marble; every sort of writing, can be thus traced; and the execution is very rapid, whether in groovings inlaid with gold or silver, or in relief, which can also be gilded or silvered.

Mastic for Repairs.—Mastic for stopping up holes, leakages or cracks in marbles, is made with gum lac, coloured as nearly as possible, to imitate the marble upon which it is used. Sometimes the gum is mixed with marble dust passed through a silken sieve; in other cases little pieces are used, which are cut and adjusted in the hole to be repaired, and glued there with the gum mastic—the precaution being first taken to heat the marble and the pieces, and to take measures for producing a perfect cohesion.

Cement Mastic.—(*a*) Thick mastic is composed of 2 parts wax, 3 of Burgundy pitch, and 8 of rosin; melt and throw into spring water to solidify the paste, then roll it into sticks, and, in using it, melt only so much as is immediately required; this will preserve its strength, as it becomes more brittle by repeated heating.

(*b*) Corbel mastic is used in seams of the flagging of stairways and terraces. Six parts of the cement of good Burgundy tile, without any other mixture, pass it through a silken sieve, add 1 part of pure white-lead, and as much litharge, steep the whole in 3 parts of linseed-oil and 1 of lard-oil, and preserve in cakes or rolls as the preceding. All the materials used should be thoroughly dry, so that they may perfectly mix with the oil which unites them.

(*c*) Fountain mastic is made of the rubbish of stoneware or of Burgundy tile, amalgamated with thick mastic in such a manner as to form a paste proportioned to the use for which it is required; this is one of the easiest to prepare.

(*d*) Mastic of filings is employed in places which are usually damp, or which constantly receive water, as curb stones, flaggings of kitchens, bath-rooms and water-closets, and stone troughs composed of several pieces, either separate or clasped. This mastic is composed of 26½ lb. of iron filings, or of iron and copper, which must not be rusty, 4½ lb. of salt, and 4 garlics; this is infused for 24 hours in 3½ pints of good vinegar

and urine; it is then poured off, and the thick paste which is found at the bottom of the vessel is the mastic, which should be immediately used.

These mastics should be used upon materials which are perfectly dry, otherwise they do not incorporate well. Choose dry weather, and open the seams well with a curved, sharp instrument, finally polishing them with the chisel. Before laying the mastic, remove the dust from the seam by blowing into it with bellows; a long, straight, iron chafing dish, closed at the bottom, with the grate elevated about an inch to obtain a current of air, is then passed over the seam; this chafing dish is filled with burning charcoal, the heat of which draws out the moisture from the stone or marble. The slightest dust or dampness hinders the adherence of mastic.

Cold Mastic. — Hydrochlorate of ammonia, 2 parts; flowers of sulphur, 1 part; iron filings, 16 parts. Reduce these substances to a powder, and preserve the mixture in closely-stopped vessels. When the cement is used, take 20 parts of very fine iron filings, add 1 part of the above powder, mix them together, adding sufficient water to form a manageable paste; this paste, which is used for cementing, solidifies in 15 days or 3 weeks, in such a manner as to become as hard as iron.

Masons' Mastic.—Pulverised baked bricks, quicklime, wood ashes, equal parts. Mix thoroughly, and moisten with olive-oil. This mastic hardens immediately in the air, and never cracks beneath the water.

Stuccoes.—Stucco is a composition of slaked lime, chalk, and pulverised white marble tempered in water, designed to imitate different marbles used in the interior of buildings or monuments. Calcined plaster-of-Paris is also used. Although the plaster becomes very hard when properly calcined, it is too porous to admit of polishing it as marble. To remedy this, the plaster is wetted with glue or gum water, which, filling the pores, allows a polish to be given it. Some mix the glue with isinglass or gum arabic. Hot glue water is used for the solution of the plaster, as the want of solidity of the plaster demands that a certain thickness should be given to the works; to lessen expense, the body or core of the work is made of common plaster, which is covered with the composition just described, giving it about an inch in thickness. When the work is dry, it is polished in nearly the same manner as real marble. Pumice may be used. The work is rubbed by the stone in one hand, the other holding a sponge filled with water, with which the spot which has just been rubbed is instantly cleansed, to remove what has been left on the surface of the work; the sponge should be frequently washed and kept filled with fresh water. The marble is then rubbed with a linen cushion, with water and chalk or tripoli stone. Willow charcoal, finely pulverised and sifted, is substituted for this to penetrate better to the bottom of the mouldings, water being always used with the sponge, which absorbs it. The work is finished by rubbing it with a piece of felt soaked with oil, and finely powdered with tripoli stone and afterwards with the felt moistened with the oil alone. When a colour is wished in the ground, add it to glue water, before making use of it to temper the plaster. When any particular marble is to be imitated, dilute with warm glue water, in different small pots, the colours of which are found in the marble; with each of these colours temper a little plaster, then make of each a lump nearly as large as the hand, place these lumps alternately one above another, making those of the prevailing colour more numerous, or thicker. Turn these lumps upon the side, and cut them in slices in this direction, instantly spreading them upon the core of the work, or upon a flat surface. By this means the design of the various colours with which the marble is penetrated will be represented. In all these operations the glue water should be warm, without which the plaster will

set too quickly, without giving time to work.

Wax Varnish to Preserve Statues and Marble exposed to the Air.—Melt 2 parts of wax in 8 parts of pure essence of turpentine. Apply hot, and spread thinly, so as not to destroy the lines of the figures. This varnish may be used upon statues which have been cleansed with water dashed with hydrochloric acid, but they must be perfectly dry when the application is made.

Colouring Marble. *Colours.*—Solution of nitrate of silver penetrates marble deeply, communicating to it a deep red colour. Solution of nitro-muriate of gold produces a very fine violet colour. Solution of verdigris penetrates marble $\frac{1}{12}$ in., giving a fine light green colour. Solutions of gum dragon and of gamboge also penetrate it; the first produces a fine red, and the second a yellow colour. To cause these two substances to penetrate deeply, the marble should first be well polished with pumice, after which the substances should be dissolved in warm alcohol, and applied with a small brush. All the wood dyes made with alcohol penetrate marble deeply. Tincture of cochineal, prepared in this manner, with the addition of a little alum, gives a fine scarlet colour to the marble, penetrating it $\frac{1}{4}$ inch. Artificial orpiment, dissolved in ammonia and laid on marble with a brush, quickly produces a yellow colour, which becomes more brilliant when exposed to the air. To all the substances employed, add white wax; this, when placed on the marble in a melted state, soon penetrates it. If the verdigris is boiled in wax, and then laid melted upon the marble, it will be seen on its removal, when cold, that the design has penetrated the surface to the depth of $\frac{1}{4}$ to $\frac{1}{2}$ in.

Application.—When several colours are to be successively used without blending them, proceed in the following manner. The dyes obtained by spirits of wine and the oil of turpentine should be laid on the marble when it is heated, particularly in the execution of delicate designs, but the dragon's-blood and gamboge may be used cold. For this they must be dissolved in alcohol, and the gamboge used first; the solution of this gum is quite clear, but soon becomes troubled and gives a yellow precipitate, which is used to obtain a brighter colour. The lines drawn by this solution are then heated by passing a chafing dish filled with lighted charcoal closely over the surface of the marble. It is then left to cool, after which the lines which have not been penetrated by the colour are heated in the same manner. When the yellow colouring has been applied, the solution of dragon's-blood, which should be concentrated as much as possible, is employed in the same manner as the gamboge; and while the marble is warm, the other vegetable tints which do not require so strong a degree of heat, may also be applied. The design is completed by the colours mixed with wax, which should be applied with the utmost care, as the slightest excess of heat will cause them to spread, for which reason they are less suited to delicate designs. In colouring marble, the pieces should be well polished, and free from any spots or veins. The harder the marble, the better it supports the heat necessary to the operation; alabaster and common soft white marble are not suitable for the purpose. Marble should never be heated to a red heat, as the fire then alters the texture, burns the colours, and destroys their beauty. Too slight a degree of heat is also bad; for though the marble takes the colour, it does not retain it well, and is not penetrated deeply enough. There are some colours which it will take when cold, but these never fix so well as when heat is employed. The proper heat is that which, without reddening the marble, is intense enough to cause the liquor which is on its surface to boil. The menstrua which are used to incorporate the colours should be varied according to the nature of the colour employed; a

mixture made with urine mixed with 4 parts of quicklime and 1 of potash, is excellent for certain colours; common lye of wood ashes is good for others; for some, spirits of wine, others require oily liquors, or common white wine. The colours which succeed best with the different menstrua are the following: blue-stone dissolved in six times its quantity of spirits of wine or urine, and litmus dissolved in a lye of pearlash; the extract of saffron and sap green succeed very well when dissolved in urine or quicklime, and tolerably in spirits of wine. Vermilion and cochineal dissolve well in the same liquids. For dragon's-blood use spirits of wine, which is also used for Campeachy-wood. For alkanet-root the only menstruum is turpentine. Dragon's-blood in tears gives a beautiful colour when mixed with urine alone. Besides these mixtures, certain colours can be put on dry and unmixed; such as the purest dragon's-blood for the red, gamboge for the yellow, green wax for a kind of green, common sulphur, pitch, and turpentine, for a brown colour. For all these the marble must be considerably heated, and the dry colours then rubbed upon the block. A beautiful golden colour is produced by equal quantities of the crude salts of ammonia, of vitriol, and of verdigris, the white vitriol being the best for this purpose. Grind these together, and reduce them all to a very fine powder. All the shades of red and yellow may be given to the marble with the solutions of dragon's-blood and gamboge, by reducing these gums to powder and grinding them with spirits of wine in a glass mortar. When only a little is required, mix one of these powders with spirits of wine in a silver spoon, and hold it over a heated brazier; this extracts a fine colour, and, by dipping a small brush in it, the finest veins may be made upon the cold marble. By adding a little pitch to the colouring, a black shade, or all the varieties of dark red, can be given. Archil diluted in water and applied when cold to the marble gives it a beautiful blue colour; by putting on the colouring in proportion as it dries, it becomes very fine in less than 24 hours, and penetrates deeply. If the paste of archil is used, which is a preparation of the plant with lime and fermented urine, the colour obtained will be more of a violet than blue; to obtain a perfect blue it must be diluted in lemon juice; this acid will not injure the marble, as it has been weakened by its action upon the archil. Large blue veins may thus be formed upon white marble; but as this colour is apt to spread, it will not be exact unless the coloured parts are instantly touched with dragon's-blood, wax, or gamboge, which checks it.

Cleansing Marble. (*See also* CLEANSING, Vol. I.)—Scraping marble which has been blackened or turned green by air and damp is dangerous to the design; whatever precautions may be taken, the work is always scratched more or less, and it is impossible to clean the carved parts without breaking the sculpture, or causing incongruities between the designs in relief and those which are sculptured. Soiled articles, which have not been tarnished by exposure to the open air, may be cleansed by potash water, then wash them in pure water, finish with water containing a dash of hydrochloric acid. Soap and water is often sufficient, spread on with a brush, and introduced into the sculptured parts by a somewhat stiff hair pencil.

To Remove Stains from Marble.—(*a*) Take two parts of soda, one of pumice, and one of finely powdered chalk. Sift these through a fine sieve, and mix them into a paste with water. Rub this well all over the marble, and the stains will be removed; then wash it with soap and water, and a good effect will be obtained.

(*b*) Clean with dilute muriatic acid, or warm soap and vinegar; afterwards heat a gallon of water, in which dissolve 1½ lb. of potash; add 1 lb. of virgin wax, boiling the whole for half an hour, then allow it to cool, when

the wax will float on the surface. Put the wax into a mortar and triturate it with a marble pestle, adding soft water to it until it forms a soft paste, which, laid on marble, and rubbed, when dry, with a woollen rag, gives a good polish.

(c) *Grease Stains.*—Get some finest French plaster, and make a cream with distilled water; well brush this over the parts, then bleach with chloride of lime on a piece of white cloth.

(d) Small pieces of marble may be cleaned of greasy stains or discolorations by being immersed for a few hours in refined benzine.

(e) *Oil Stains on Statuary.*—Take some fuller's earth, and with scalding water make a paste. While hot cover the stained parts, and leave for a day, then scour off with soap and water.

(f) *For a marble mantel-piece stained with oil.*—Boil together for one hour, in sufficient water to make a cream, a pound of soft soap, a pound of whiting, and ¼ lb. of crystal washing soda. A piece of blue the size of a chestnut may be added. After boiling use the mixture hot, rubbing it over the discoloured surfaces leaving a coat as thick as possible to dry on. Leave for 24 hours or longer, then wash off, and polish with flannel.

(g) Soda solution, 2 oz. of washing soda (crystals) in a quart of water, has a good cleansing effect, if the marble is well brushed with it, and frequently rinsed with cold water.

Restoring the Colour of Marble.—Mix up a quantity of the strongest soap lees with quicklime to the consistence of milk, and lay it on for 24 hours; clean it afterwards with soap and water.

Repairing Marble.—Heat the edges of the marble before a strong, clear, charcoal fire, avoiding dust or smoke, until the marble is sufficiently hot to take small pieces of shellac. Then choose a sufficient number of thin pieces, of such a size as not to project above the surface of the marble, and apply them along the edge of each piece to be joined; but in such a manner, that the bits of lac on each piece of marble will come between those on the other. Then just before applying them together, a hot iron must be passed along each piece at a sufficient distance to fuse the lac, but not to make it run. The pieces of marble must be well forced together.

Marble Cement.—Plaster of Paris soaked in a saturated solution of alum, baked in an oven, ground to powder. Mix with water.

Marble, Imitation.—The slate having been reduced to a perfectly level surface, a coating of colour is applied according to the stone it is intended to imitate. For black, tar varnish is used with good effect. The slab is then thoroughly baked in an oven heated at 130° to 250° F., for 12 to 48 hours, according to size. The colours, say grey and white, are then floated on to the surface of a cistern of water, over which they float naturally into the shapes of the streaks of colour seen in marble. The slate, with its black ground now burnt in, is dipped into the surface of the water, and receives from it a thin coat of colour. The slate again has to go into the oven, and when sufficiently hardened, a coating of enamel is applied. Another baking to harden the enamel, and the slab is then pumiced to reduce it to a level surface. Baked again, it is once more pumiced, and this time goes into the oven with the pumice wet on its surface. If necessary this last operation is repeated. The slab is then ready for polishing, which is effected firstly by woollen cloths and fine sand, next by the finest and softest French merino, and lastly, by the hand and powdered rotten-stone. The dipping process is not applicable to imitations of all stones. Some granites are best imitated by splashing; others by splashing and sponging combined, while some have to be hand-grained. Very good effects in irregular veining are obtained by applying the colour with a small roll of soft leather, the edges of which have been made ragged.

MARBLING PAPER AND BOOK EDGES.

Tools. *Wooden Trough.*—This is made of inch deal, about 1½ in. in depth and ½ in. in length and breadth larger than the sheets of paper that are to be marbled. This proportion between the size of the trough and paper should always be observed, to prevent waste of colour; of course, troughs of various sizes will be required, where paper of various sizes is to be marbled. The trough must be water-tight, and the edges of the sides of it must be sloped or bevelled off on the outside to prevent any drops of colour which may fall on them from running into the trough and sullying its contents.

A Skimmer, or clearing stick, must be provided for each trough; this is a piece of wood, 2½ in. wide, ½ in. thick, and as long as the trough it belongs to is wide inside; the use of this will be explained hereafter.

A Stone and Muller of marble, or some other hard stone, the size according to the quantity of colour required to be ground. Also a flexible knife, for gathering the colour together.

A dozen or two of small glazed *pipkins* to hold colours in. The pots being furnished with

Brushes made as follows: Take a round stick about as thick as your finger, and cut a notch all round one end of it; next, take some bristles, 4 or 5 in. long, and place them evenly round the stick, at the notched end, letting them project 1½ in. beyond the wood; fasten the bristles to the stick by several turns of stout thread; cut away the ragged bristles, and tie up the brush firmly with fine cord. The use of the notch round the end of the handle is to make the bristles spread out when firmly tied up, so that when used the colour may be scattered about more abundantly.

Rods for drying the paper on when marbled; they should be round, at least on the upper side, and about 1½ in. in breadth and thickness. Twelve rods 11 ft. long will hang 3½ quires of demy, or 4½ quires of foolscap.

Colours.—*Red*—vermilion, drop-lake, rose-pink, Venetian red, red ochre. *Blue*—indigo blue, prussian blue, verditer. *Orange*—Orange lead, orange orpiment. *Black*—ivory blue-black. *Yellow*—Dutch pink, yellow ochre, king's yellow, English pink. The finer the colours are ground, the better and the cheaper will the work be. First the colours should be finely pounded, then mixed with water to the consistence of paste, and put in a colour pot with the knife. From the pot, the colour must be taken out a little at a time, and levigated very fine with pure water.

Compound Colours are made by mixing the colours above mentioned in certain proportions. To make a red colour, mix three parts of rose-pink with 1 of vermilion. A finer red—4 parts of rose-pink, 2 parts of vermilion and 1 part of drop-lake; for very fine work use drop-lake alone, but use it very sparingly, for it is a dear article. Yellow—2 parts of Dutch pink, and 1 part each of king's yellow and English pink. Green—made by mixing blue and yellow. Dark blue—indigo, which may be made lighter by the addition of verditer. Orange brown—2 parts of Venetian red, and 1 part of orange lead. A fine orange—put some fine yellow ochre in a ladle over a fire, and keep it there till it assumes a dark red colour. Take of this red ochre, finely pounded, and of Venetian red, equal quantities, and add a little orange orpiment or rose-pink; mix all well together. Umber colour—equal quantities of Venetian red, orange lead and ivory black; this can be lightened with orange lead, or darkened with ivory black. Cinnamon colour—Venetian red with a little prussian blue. All other colours which may be wanted can be made by mixing together those already described. In addition to the articles already mentioned, obtain a bottle of ox-gall, a bottle of good oil

of turpentine, some pure water. The trough must be filled to within ½ in. of the top, with a solution of gum tragacanth, which is prepared as follows: Gum of a pale white semi-transparent appearance is to be soaked in water for at least 48 hours, in the proportion of ½ lb. to 1½ gallon. Pass the solution of gum through a hair sieve or linen cloth, and pour it into the trough. In all cases, when the trough is to be used, the solution should be well stirred up with a few quills, and the surface of it cleared from film by the skimmer above described.

Colours intended to represent Veins are made by adding a small quantity of gall to the various colours, and stirring each well up with a brush, in order that they may be properly mixed. Previous to use, these mixtures of colour and gall are thinned with water to the consistence of cream, and well stirred up.

Colours for producing Spots like Lacework.—Take some dark blue, or other colour, add some gall to it, and about as much, or a litttle less, oil of turpentine; stir all well together, and dilute with water. To try the colours throw on the solution, by shaking the various colour brushes over it, some spots of colour. If the spots spread out larger than a crown-piece in size, the colours have too much gall; if the spots, after spreading out a little, contract again, there is too little gall in them. In the one case, more colour must be added, in the other more gall. If the colours are in good order, and paper is to be marbled, the whole surface of the solution in the trough must be covered by colours, in spots, streaks, or whirls, according to the pattern required, and laid on according to directions which will be given presently. The paper should be previously prepared for receiving the colours, by dipping it overnight in water, and laying the sheets on each other with a weight over them. The sheet of paper must be held by two corners, and laid in the most gentle and even manner on the solution covered with the colours, and there softly pressed with the hand that it may bear everything on the solution, taking care not to let the colours flow on to the back of the paper any more than can be avoided: after which it must be raised and taken off with the same care, and then hung to dry over the rods.

Patterns.—(*a*) Throw on red till the solution is nearly covered, then some yellow, black and green; add, if desired, a little purple with plenty of gall and water in it; twist the colours into any shape by means of a quill.

(*b*) Throw on red, yellow, black and green, as before: but, for a last colour, add some of the dark blue mixed with turpentine.

(*c*) Throw on red, yellow, black and green, in the desired proportion; then with a quill draw lines through the colours; after which throw on a greater or less quantity of blue, green, pink, or purple, much diluted, and containing plenty of gall and turpentine.

(*d*) Throw on very fine red for veins; then plenty of the turpentine blue. If the colours are good, this produces a handsome pattern in a short time.

(*e*) Throw on some dark blue mixed with turpentine, and take this up with a paper previously stained of a yellow, light blue, red, pink, or green colour. To obtain a good green for this purpose, boil French berries in water, add a little spirit or liquid blue, and carefully brush over the paper, which must be good and well sized, with this mixture.

When the colours become too thick for use, add fresh ground colour with water and a little gall to them, and stir them up well. Be particular in getting good turpentine. When the solution of gum gets dirtied, throw it away and make a fresh one. The neatest and most convenient method of marbling the edges of books is to dip one volume at a time, doing the ends first, and throwing back the boards to do the fore-edge; observing to hold the book tight with both hands, and not to dip deeper than the surface, to prevent the solution from

spoiling the book. It is the safest way to tie the book between boards before dipping; and, for the sake of convenience and economy, when only a few books are to be marbled, a small trough should be used.

Marbled paper is glazed by a machine similar to that with which cottons are glazed. But a machine of this kind would only be required by those who marble very largely. Book edges are polished by the agate burnisher, and so might small pieces of paper be polished, which were required for any particular purpose. Good common pressing, or hot-pressing, might serve as well as glazing. For any fancy work it would have a fine effect to varnish the marble paper after it had been put to its destined purpose and had become dry. Paste and all moisture chase all the glaze away. The application of a coat of varnish subsequent to the application of paste would double the beauty of the best marble paper, and much improve the common kind, at a trifling expense.

MATCHES.

MATCHES consist of two essential parts a combustible stem (except in the case of fusee pipe-lights in which case the stem is usually non-combustible) and an igniting composition. In the "safety" matches the igniting composition is divided into two parts, for the head of the match owes its ignition not to itself but to the material on the box.

For the purpose of this article the preparation of the wooden stems—splints, as they are called—from the wood logs, must be omitted, this involving the use of machinery on a very large scale. Should particulars of this be required a full account may be found in Spons' 'Encyclopædia of Industrial Arts.' In this article description must be largely restricted to the receipts for the igniting compositions.

The compositions used on the ends of matches to provide for ignition may be said to be of two kinds only, viz. those for "strike anywhere" matches, and those for the safety or "strike-only-on-the-box" kind. In addition there is the composition which forms the mass of the burning material of the fusee or vesuvian pipe-lights.

The safety match which for all general purposes may be said to ignite only by rubbing it on the composition on the box is a distinctly ingenious invention, for the match by itself is free of the risk of accidental ignition which is so often experienced with the "strike-anywhere" variety. It is not incorrect to say that it is the thin coat of composition on the side of the box that "strikes," for it is this that provides for and actually causes the ignition; therefore, while the matches are inside the box, and the igniting composition is outside, an excellent degree of safety is provided for.

Of late years this safety match has been made safe in a different and additional way, this being by the impregnation of the wood of the stem,

so that while it is burning or afterwards, it has little or no glowing condition and the burnt stem remains a stiff piece of black charcoal, instead of glowing away to ash and dropping a red-hot head on the floor. This is an excellent feature.

In the case of cheap matches, the stem is made of wood. The wood most generally used is soft pine, which is sawn into blocks to fit the machine. The wood having been cut into splints is taken out and tied up into bundles of a thousand each and then thoroughly dried by being left in a heated chamber for some time. The next process used to be to dip the ends in melted sulphur (commonly done by hand) the dipper giving to the bundle a kind of twist which makes the ends spread out a little, so that they get coated all round with the sulphur, and do not stick together in cooling. Each end is dipped in turn, and, when dry, the bundles were cut through the middle by a circular saw. The object of dipping them first in sulphur was to supply a substance which would readily take fire on the ignition of the compound with which the end is afterwards tipped. The fumes of burning sulphur are, however, disagreeable, and matches are therefore made without it. In this case, the ends of the splints may be slightly carbonised by pressing them for a moment upon a plate of red-hot iron, and then just touched with melted paraffin, a small quantity of which is at once absorbed by the wood. These burn even better than the preceding, as the wood then takes fire immediately, while in the others it does not until the sulphur is nearly burnt out. The paraffin is a little more expensive; but on the other hand, a much less quantity will answer the purpose, and the matches so made are altogether preferable for the consumer. A solution of paraffin in benzine is now largely used for first dipping.

The next step is to apply the material which is to be the source of fire, and which, with "strike-anywhere" matches, must be of such a nature as to take fire readily with moderate friction. This composition is made up into a pasty mass, the most important ingredient being phosphorus; but both the proportions and the subsidiary articles vary greatly in different manufactories. The object is to make a paste which, when dried, will not be affected by exposure to the atmosphere, which may be readily ignited with moderate friction, and which shall be sufficiently tenacious to adhere firmly to the end of the splint until the wood has taken fire. Ordinary phosphorus cannot be preserved in a dry condition in the air, as it rapidly oxidises and takes fire spontaneously, emitting very poisonous fumes at the same time. It has therefore to be kept constantly under water, and except in combination with other substances, would be most unsuitable for domestic use. Chlorate of potash which is a highly explosive substance is free from some of the objections attaching to phosphorus, and is substituted for it by some makers. Most, however, use a little of each in their paste. The worst feature of the chlorate of potash is its readiness to explode on a very slight concussion, the violence of its action throwing off sparks which might prove dangerous. Matches containing much of this article may be recognised by the sharp detonation with which they go off; those which are called "noiseless" contain no chlorate of potash. These are the light-bearing ingredients. The rest are glue or gum to give them coherence; some fine sand or pulverised glass, to give increased friction; and some substances which will readily give up a large amount of oxygen—such as nitrate of potash, the peroxides of lead or manganese, and sulphide of antimony to promote rapid ignition. Some mineral colouring matter is added, according to the fancy of the manufacturer. It will be quite unnecessary to go into detail as to the relative proportions which may be used, for they may be varied almost infinitely. Even the most important article of all, the phosphorus, varies in quantity

from 5 to 50 per cent. The larger proportions are generally to be found in those which contain no chlorate of potash.

The matches made on the Continent are compounded with gum; but in England, glue is generally used, because of the greater humidity of this climate. The plan adopted in mixing the ingredients is as follows: The glue is broken into small pieces and put into cold water, in which it is left to soak for some time; it is then boiled up gently until thoroughly dissolved. The pot is then taken off the fire, and the required proportion of phosphorus is gradually added. It melts immediately with the heat of the watery glue, but it must be kept constantly stirred to make it mingle thoroughly, care being taken to keep it below the surface of the liquid. The other articles are then added, and the stirring is maintained with vigour, as the compound thickens both with the cooling and with the addition of the solid ingredients; it must, however, be kept in a pasty condition, and therefore the temperature is not allowed to fall below about 97° F. (36° C.). The paste is then spread in a thin layer upon a flat table of marble or iron, which is kept just sufficiently warm to maintain the glue in a soft condition until the dipping has taken place. If gum be used instead of glue, no artificial heat is required at this stage of the process, as it will not solidify by cooling. The paste is spread evenly upon the table to an exact depth, so that in dipping the matches one shall not get a larger share of the composition than another. After dipping, they are left to dry for 3 or 4 hours in the air, and then are placed for 2 hours in a heated chamber, the temperature of which is maintained at 80° to 90° F. (27° to 32° C.). The matches are by this time finished and ready for packing.

The question whether or not "safety matches" will ignite when rubbed on other surfaces than "the box" has been practically settled in the affirmative, but under such circumstances that the fact does not detract from their merit as "safety" matches. The answer to the question would seem to depend entirely on whether the surface on which the match is rubbed is capable of imparting sufficient heat by friction to fire the paste with which the end is tipped. Linoleum has been found to answer, and it has been proved that the matches light on ebonite. Tomlinson succeeded in igniting safety matches by friction against glass, an ivory paper-knife, a steel spatula, zinc, copper, marble, and a fresh cleaved surface of slate. For the sake of strength, two matches should be taken and held close to the tipped end and they must be rubbed with some degree of pressure.

The readiness with which the match ignites by friction, says Tomlinson, depends greatly on the nature of the surface. Lead is too soft, and tin too smooth. The metals produced by rolling have a sort of skin on the surface, over which the match glides without sufficient friction, but if the surface of zinc be rubbed with sand-paper, or with a fine file, it becomes active in firing the match. He noticed that the polish of his ivory paper-knife became worn before it acted well. Nor is it very easy to fire the match on glass. A long sweep repeated about a dozen times with considerable pressure seems to be necessary. The two specimens of sheet copper used by him had a sort of grain which was favourable to the success of the experiment. The copper acted equally well whether the surface was dirty or cleaned with dilute sulphuric acid. After rubbing a match 10 or 12 times on zinc, without effect, the same match rubbed on copper immediately took fire. As a rule, it may be taken that polished surfaces will not ignite the matches until the polish itself is destroyed by the friction.

He thinks that many other surfaces might be found on which the safety matches would ignite with greater or less difficulty. Notwithstanding this, the match is still a safety match, although it does not fulfil the statements

made on the box. It does not ignite readily on any of the surfaces pointed out, except copper and marble (unpolished), but it does ignite with wonderful facility when rubbed against the side of the box.

Ordinary matches made with phosphorus were during many years dangerous contrivances. They were luminous in the dark, liable to ignition on a warm mantelpiece, poisonous—children have been killed by using them as playthings; and, moreover, they absorbed moisture, and became useless by age. But the chief inducement in getting rid of ordinary phosphorus and substituting the new variety was to put an end, as far as possible, to the "jaw disease" to which the workmen were subject. The red or amorphous phosphorus gives off no fumes, has no smell, is not poisonous, and the matches made with it are not luminous in the dark; they do not fire on a warm mantelpiece, do not contract damp, and will keep for any length of time. But there is a difficulty. When red phosphorus is brought into contact with potassic chlorate, a slight touch is sufficient to produce an explosion, in which the red phosphorus reassumes its ordinary condition. Many attempts were made to form a paste, and many accidents and some deaths occurred in consequence. At length the happy idea occurred to a Swedish manufacturer not to attempt to make a paste at all with the red phosphorus, but to make the consumer bring the essential ingredients together in the act of igniting the match.

Wax Vestas.—In making wax vestas, the first process is the coating of the cotton. A number, say 20, of strands or wicks, composed of 15 to 20 threads each, are led from a bale placed upon the ground, through guides arranged overhead, down into an oval steam-jacketed pan, filled with wax composition, underneath a presser arranged in the centre of a pan, and through a draw-plate pierced with holes of the required gauge of the match-body; thence it is led some 15 or 16 ft. over a drum 5 or 6 ft. in diameter, and then to a similar drum on the opposite side of the bath, from which it is repeatedly passed through the paraffin, wooden guides being arranged to support the wick wherever necessary. The distance traversed after the cotton has passed through the bath is made as long as possible, since the composition neither dries so readily, nor adheres so uniformly to the strand, as in the after-dipping. It is passed and repassed about 6 times through the bath, until the wax coating is of sufficient thickness, and just passes the holes in the gauge-plates. Considerable care is necessary to ensure evenness in the first coating, and to watch against broken threads.

The drum has a metallic plate on one part of its circumference, and here the wax taper is cut into lengths of the circumference of the drum, is tied in bundles, and is carried to the table having partitions to hold each bundle of lengths. The lengths are pressed against a gauge, and cut up by means of a knife working on a pivot. The match-stems so cut off are carefully transferred to shallow zinc frames, constructed of the required depth, and made with a lid which is slid down when the frame is filled; they are then carried to a filling-machine of a small size, and usually worked by hand. Here they are filled into dipping-frames in the same way as ordinary matches, the machine having its hopper arranged to suit the size of the bodies. Wax matches can be dipped in the same way as those of wood; but some years since, S. A. Bell devised a machine in which frames are attached to two chains running on either side of guides. Between them, a flannel roller revolves in a pan of liquid composition. The frames, with the splints arranged downwards, run over this roller, and the composition is thereby added to the bodies with considerable regularity and dispatch. The machine will dip 3500 to 4000 frames a day, and since each frame holds about 4500 splints, it will dip about 18,000,000 splints in that time. The drying is effected, when

practicable, in the open air, the frames standing together in twos or fours. At other times, the splints are dried by hot air, distributed by means of revolving fans, in rooms set apart for the purpose. After drying, they are sorted and packed in boxes of various size, pattern, and capacity.

Vesuvians or Fusees.—The "vesuvians," principally used as lights by smokers, have rounded splints, made from alder, or some similarly hard wood, the object being to prevent the ignition of the wood, and consequent dropping of the burning composition. The more expensive kinds are made on glass bodies, consisting of glass piping of small section, which is chiefly procured from Italy, and should yield some 1200 splints to the lb. An ingenious method of retaining the composition is by means of a piece of wire, about ½ in. long, inserted by hand into the end of each splint; it answers the purpose effectually. The vesuvian-splints are placed in moulds and the composition for the heads pressed on them. After drying, the heads are tipped with the striking composition like an ordinary match.

Compositions.—Igniting compositions for "strike-anywhere" matches are generally manufactured of some form of phosphorus mixed with oxidising agents, with which it will readily inflame by friction. Such are saltpetre, chlorate of potash, and red-lead; these are mixed up with glue, which causes them to adhere to each other and to the wooden splints. Most makers have a particular mixture of their own; the following practical recipes may be taken as fairly representative, the first being the best: (1) ½ part by weight red phosphorus, 4 chlorate of potash, 2 glue, 1 whiting, 4 finely powdered glass, 11 water; (2) 2 parts by weight phosphorus, 5 chlorate of potash, 3 glue, 1½ red-lead, 12 water.

The match composition is coloured either with a coal-tar colour, ultramarine blue, prussian blue, or vermilion. In preparing the composition, the glue and the nitre or chlorate of potash are dissolved in hot water, the phosphorus is then added, and carefully stirred in until intimately mixed, the whole being kept at a temperature of about 100° F. (38° C.). The fine sand and colouring matter are then added, and the mixture is complete.

The Germans replace the chlorate either by nitrate of potash or nitrate of lead, together with red-lead, hence their matches strike silently, without the short detonation peculiar to English goods.

Vestas are tipped with similar ingredients, but the taper being less rigid than wood, a larger proportion of phosphorus is added.

(3) English Matches.—2 parts fine glue soaked in water till quite soft, 4 parts water, heated together in a water-bath till quite fluid; remove the vessel from the bath, and add 1½ to 2 parts phosphorus, agitating the mixture briskly and continually with a stirrer having wooden pegs or bristles projecting beneath. When the mass is uniform, 4 or 5 parts chlorate of potash, 3 or 4 parts powdered glass, and sufficient colouring matter in the form of red-lead, smalts, etc., are cautiously added, and the whole is stirred till cool. These matches ignite with the recognised snapping noise.

Silent Matches.—(1) Dissolve 16 parts gum arabic in least possible quantity of water, triturate in 9 parts powdered phosphorus, and add 14 parts nitre, 16 parts vermilion or binoxide of manganese, and form the whole into a paste.

(2) 6 parts glue soaked in a little cold water for 24 hours, and liquefied by trituration in a heated mortar; add 4 parts phosphorus, and rub down at a heat not exceeding 150° F. (66° C.); mix in 10 parts powdered nitre, and then 5 parts red ochre and 2 parts smalts, and form the whole into a uniform paste.

(3) Instead of phosphorus, lead sulphocyanate mixed with precipitated antimony sulphide is treated in the moist state with an oxygenous sub-

stance, such as potassium chlorate, with indifferent colouring and rubbing agents, such as glass, quartz, pumice powder, ultramarine, etc., and with glutinous substances, such as glue, gum, and dextrine. The mixture is used in place of the materials employed for igniting sulphur matches, wax lights, etc. (H. Schwarz.)

(4) Phosphorus, 17 parts; red-lead, 24 parts; nitre, 38 parts; fluid glue, 21 parts.

Safety Matches.—(1) Dipping composition for safety matches consists of 1 part by weight chlorate of potash, 2 glue, 1 sulphide of antimony, 12 water. For the rubber on the box, 2 parts of amorphous phosphorus and 1 of powdered glass are mixed with the solution of glue, and painted on the box.

(2) Dipping composition.—4 parts chlorate of potash, 1½ part bichromate of potash, 4 parts red lead, 3 parts sulphide of antimony, glue and water to make a creamy paste. For the rubber on the box, 2 parts phosphorus, 1 part glass dust, glue and water to make a paint.

(3) Dipping composition.—Chlorate of potash, 200 parts; lead binoxide, 115; red-lead, 250; antimony trisulphide, 125; gum arabic, 67; paraffin, 25; bichromate of potash, 132. Rub the antimony and paraffin together, then add the other ingredients. Add water to make the whole of a proper consistency when heated over a water bath. For the rubber on the box, 9 parts red phosphorus, 7 parts powdered iron pyrites, 3 parts powdered glass, liquid gum arabic or glue to make a paint.

(4) Matches from Sweden were found to be tipped with an igniting composition made up of the following substances:—

	In 100 parts.
Glass	8·77
Glue	7·12
Potassic bichromate	5·59
Potassic chlorate	46·76
Ferric oxide	4·09
Manganese	13·07
Sulphur	7·41

It is supposed that the following proportions were employed in the manufacture of the composition:—

Glass	1¼ lb.
Glue	1 „
Potassic bichromate	¾ „
Potassic chlorate	6¾ „
Ferric oxide	½ „
Manganese	2 „
Sulphur	1 „

In consequence of the small proportion of oxygen-yielding substances to sulphur, a large quantity of sulphurous acid is evolved on igniting the mass.

(5) In another composition, likewise from Sweden, Wiederhold found to 1 of sulphur 21 of potassic chlorate; this composition yielded no free sulphurous acid, the sulphur being wholly oxidised to sulphuric acid. ('Dingler's Polyt. Journ.')

Vesuvians or Fusees.—The heads of vesuvians are made up principally with powdered charcoal and saltpetre in some such proportions as the following: 18 parts saltpetre, 19 charcoal, 7 powdered glass, 5 or 6 gum-arabic; to these ingredients are added a little scent, in the form of satin-wood, lignum-vitæ dust, cascarilla bark, or gum benzoin, which render them fragrant while burning. The igniting composition is identical with (1) or (2).

Red Phosphorus varies in colour from a red to brown. It is made by heating ordinary phosphorus to 240°C. in a closed retort (or in an inert gas like carbonic acid or nitrogen). It then changes its character, not igniting so freely as ordinary phosphorus, and, if pure, is non-poisonous. The latter quality should not be relied on as red phosphorus commonly carries some ordinary phosphorus in its composition.

Phosphorus Substitute.—G. Graveri states that persulphocyanic acid ($H_2(CN_2)S_3$) meets all the requirements of phosphorus for matches, resisting shock and friction, is readily friable and will mix with other substances, is non-poisonous and cheaper than phosphorus.

Impregnating Fluid for Wood Stems.—(*a*) A $2\frac{1}{2}$ per cent. solution of ammonium sulphate; (*b*) a solution of ammonium phosphate (2 per cent. of this salt with 1 or $1\frac{1}{2}$ per cent. of phosphoric acid).

MEASURING ANGLES.

A SIMPLE means of measuring angles is shown in Fig. 40. The board *a* usually of deal, which should be about 15 in. square, underneath it has screwed on to it in the centre a brass boss, which fits into a similarly shaped recess in the wooden head of a folding tripod stand. A brass clamping screw

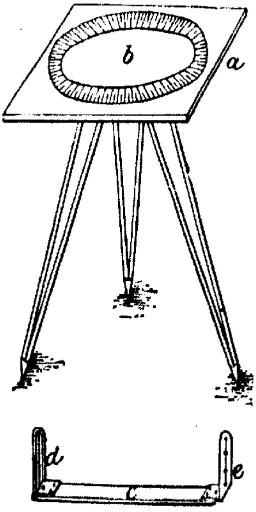

FIG. 40.

passes from below through a hole in the centre of the tripod head, and screws into the brass boss on the board. By this means the board, or plane table, as it is here termed, can be smoothly turned round horizontally into any position and securely clamped there.

On the top of the board is pasted or glued a cardboard protractor *b*. These protractors are about 12 in. diameter, and are graduated to $\frac{1}{2}$ degree, and can be bought for a small sum. Care

should be taken to attach this flatly to the board.

The next essential is a sight-rule *c*. This consists of a flat piece of some hard wood about 15 in. long by 2¼ in. wide, and ⅜-½ in. thick, having one edge bevelled. On each end is fitted centrally a brass sight-vane—one *d* having a wide slot through its up standing part, down the centre of which is fitted a fine wire or hair; the other *e* has a fine slit down its centre.

To measure an angle between two objects, the plane table is set up as level as possible by eye, the sight rule is placed across the centre of the protractor, and pointed in the direction of the left-hand object, the eye being applied to the slit in *e*, and the wire in *d* being brought into coincidence with the object. Care must be taken that the bevelled edge of the rule lies nearly over the centre of the protractor. This is easily ensured by placing the finger or the uncut end of a pencil touching the centre point, and using this as a pivot round which to turn the rule. The graduations of the protractor cut by the bevelled edge of the rule are then read at each end, and their mean is taken as the true direction of the object. A similar observation is then taken to the right-hand object, care being always taken to use the mean of the readings at each end of the rule. The difference between the readings to the two objects give the angle required.

A most surprising degree of accuracy can be obtained by the use of this simple instrument by repeating the observations on a different part of the graduation. It is, in fact, a very fair theodolite without the telescope.

If a magnetic compass is used in conjunction with the plane table, and by its means the table and protractor be turned round and set magnetic north and south, accurate magnetic bearings of objects can be obtained with equal facility. (G.)

METAL COLOURING AND DECORATING.

(*See also* JAPANNING AND LACQUERING.)

Bronzing. — *Steel Bronze for Brass.*—Mix up 1 oz. oxide of iron, 12 oz. hydrochloric acid, and 1 oz. of white arsenic. Clean the brass well to get rid of lacquer or grease, and apply with a brush until the desired colour is obtained. Stop the process by oiling well, when it may be varnished or clear lacquered.

Black Bronze.—Dip the article bright in aquafortis; rinse the acid off with clean water, and place it in the following mixture until it turns black: hydrochloric acid, 12 lb.; sulphate of iron, 1 lb.; and pure white arsenic, 1 lb. Then take out, rinse in clean water, dry in sawdust, polish with black-lead, and then lacquer.

Red Bronze.—Dissolve oxide of iron in nitric acid, to this add from 25 to 50 per cent. of water and a few iron borings or turnings, free from oil. Dip the articles in this mixture. If too strong, they will, at once turn black, then add more water until the proper shade is obtained. Polish with oxide of iron, and then lacquer with gold lacquer.

Brown Bronzes.—Different shades of browns may be obtained by immersion in a solution of nitrate or chloride of iron. The various shades can be obtained by adjusting the strength of the bath.

To Bronze Copper.—First well clean the surface of the work, then brush carefully over with a solution of acetate of copper, or peroxide of iron, in sulphate of iron. Heat the work slowly, and then rub the powder off. Repeat the process if required.

Bronze for Brass.—1 oz. muriate of ammonia, ½ oz. alum, and ½ oz. arsenic if well dissolved in 1 pint vinegar, will make bronze for brass.

To Bronze Steel.—A cheap method is to simply take the parts that require

bronzing, and to cover them with olive-oil, then take a kettle of boiling water and expose the oiled parts to the steam.

Violet Bronze.—Many shades of violet can be obtained by immersion in a solution of chloride of antimony. The different shades can be ascertained by the strength of the bath.

Green Bronze.—Mix 12 oz. nitrate of iron, 2 oz. nitrate of soda, and 1 pint of water. Dip the articles in this mixture until they have received the required shade, wash them in clean water, dry, and afterwards dip them in the following mixture: 1 oz. perchloride of iron and 2 oz. of water. When the articles are quite dry, apply a coat of suitable lacquer.

Olive Green Bronze.—This can be produced by a solution of arsenic and iron in muriatic acid. Polish afterwards, with the Plumbago brush, then when warm, coat it over with a lacquer composed of the following: 1 part powdered turmeric, 1 part gamboge, and 1 part varnish lacquer.

Steel Grey Bronze.—(*a*) This can be produced on brass work by means of arsenic chloride, and blue by well boiling and attentive treatment with a strong sulphide of soda.

(*b*) Another method is to mix vinegar or dilute sulphuric acid (1 acid 12 water) with powdered black-lead in a saucer or open vessel; apply this to the brass with a soft plate brush by gently brushing. This will soon assume a polish, and is fit for lacquering. The brass must be made slightly warmer than for lacquering only. A little practice will enable the operator to bronze and lacquer with once heating. The colour, black or green, varies with the thickness of black-lead.

Florentine Bronze.—Mix together 1 dr. sal-ammoniac, 15 gr. oxalic acid, and 1 pint pure vinegar.

Rich Green Bronze.—Boil slowly together ½ oz. sal-ammoniac, 1 qt. wine vinegar, ½ oz. alum, 1 oz. green verditer, 4 oz. of French berries, and 1 oz. common salt.

Red Brown Bronze.—(*a*) Dissolve in vinegar two parts verdigris and one part sal ammoniac. Boil, skim, and dilute with water, until white precipitate ceases to fall. Set in a pan meanwhile the articles to be bronzed, made perfectly clean and free from grease. Boil solution briskly, and pour over articles in the pan and bring again to the boil. A bright reddish-brown colour is thus acquired; but the articles should be frequently inspected, and removed as quickly as the desired shade is obtained. Then they are to be repeatedly washed and dried. The solution must not be too strong, for then the bronze will come off by friction, or turn green on exposure to the air.

(*b*) Dissolve 2 oz. of nitrate of iron, and 2 oz. of hyposulphite of soda in 1 pint of water. Immerse the articles in the bronze till of the required tint, as almost any shade from brown to red can be obtained; then well wash with water, dry, and brush. One part of perchloride of iron, and two parts of water mixed together, and the article immersed in the liquid gives a pale or deep olive green, according to the time of immersion. If nitric acid is saturated with copper, and the article dipped in the liquid, and then heated, it assumes a dark green. If well brushed it may be lacquered with pale gold lacquer, or else polished with oil.

Antique Green.—The repeated applications of alternate washes of dilute acetic acid and exposure to the fumes of ammonia will give a very antique-looking green bronze; but a quick mode of producing a similar appearance is often desirable. To this end the articles may be immersed in a solution of 1 part perchloride of iron in 2 of water. The tone assumed darkens with the length of immersion. Or the articles may be boiled in a strong solution of nitrate of copper. Or lastly they may be immersed in a solution of 2 oz. nitrate of iron and 2 oz. hyposulphite of soda in a pint of water. Washing, drying, and brushing complete the process.

Various Bronzes.—Before bronzing, all the requisite fitting is finished, and

the brass annealed, pickled in old or dilute nitric acid till the scales can be removed from the surface, scoured with sand and water, and dried. Bronzing is then performed according to the colour desired; for although the word means a brown colour, being taken from the Italian *bronzino*, signifying burnt brown, yet in commercial language it includes all colours. Browns of all shades are obtained by immersion in solutions of nitrate or perchloride of iron; the strength of the solutions determining the depth of colour. Violets are produced by dipping in a solution of chloride of antimony or of permuriate of iron. Chocolate is obtained by burning on the surface of the brass moist red oxide of iron, and polishing with a very small quantity of black-lead. Olive green results from making the surface black by means of a solution of iron and arsenic in muriatic acid, polishing with a blacklead brush, and coating it, when warm, with a lacquer composed of 1 part lac-varnish, 4 of turmeric, and 1 of gamboge. A steel-grey colour is deposited on brass from a dilute boiling solution of muriate of arsenic; and a blue by careful treatment with strong hyposulphite of soda. Black is much used for optical brass-work, and is obtained by coating the brass with a solution of platinum, or with chloride of gold mixed with nitrate of tin. The Japanese bronze their brass by boiling it in a solution of sulphate of copper, alum, and verdigris. Success in the art of bronzing greatly depends on circumstances, such as the temperature of the alloy or of the solution, the proportions of the metals used in forming the alloy, and the quality of the materials. The moment at which to withdraw the goods, the drying of them, and a hundred little items of care and manipulation, require attention which experience alone can impart. ('Eng. Mechan.')

Bronzing Process used in the Paris Mint.—Powder and mix 1 lb. each of verdigris and sal ammoniac. Take a quantity of this mixture as large as a hen's egg, and mix into a dough with vinegar. Place this in a copper pan (not tinned), boil in about 5 pints of water for 20 minutes, and then pour off the water.

For bronzing, pour part of this fluid into a copper pan; place the medals separately in it upon pieces of wood or glass, so that they do not touch each other, or come in contact with the copper pan, and then boil them in the liquid for ¼ hour.

Bronzing Copper.—(*a*) Bronzing copper by the well-known method of heating it over a fire is a tedious and not altogether satisfactory process. It involves the exercise of some skill, and a considerable amount of labour must be expended in the preliminary processes of cleansing and polishing; and very often the whole operation has to be performed over again, owing to some accidental blemish imparted to the surface of the article in some subsequent process—e.g. brazing or soldering. The polishing powders principally employed are crocus and plumbago, the latter giving a deeper and more permanent colour to the finished article than the former, while shades between can be obtained by mixtures of the two powders. There are several secret processes employed by the principal workers in the art, the substances used in which are known, but the exact methods are undescribed. Potassium sulphide and ammonia hydrosulphate are both capable of imparting to the surface of clean copper an appearance of antique bronze. The solution is brushed on carefully and allowed to dry, the metal being previously heated to about 70° F. A solution of verdigris and sal ammoniac in vinegar, diluted with water, boiled and filtered, is used as a sort of pickling bath for brass and copper articles it is desired to bronze. The bath must be kept at the boiling point, and care must be taken that the articles are removed as soon as the desired effect is produced. A bronze, said to be used by the Chinese, is made, like the last, of sal ammoniac

and verdigris, with the addition of alum and vermilion (i.e. the pure article prepared from mercury and sublimed sulphur). These ingredients, when reduced to a fine powder and made into a paste with vinegar, are spread over the surface of the article to be bronzed, which is then placed in an oven, where it heats slowly but uniformly. When thoroughly warm, the paste is carefully washed off in hot water, and the article is rapidly dried, with the assistance of hot box sawdust, if of special value. If the bronzing is not of a sufficiently deep tone, the process is repeated immediately after the washing. The common bronzing solution for metallic statuettes is made by dissolving about 1 part potassium binoxalate and 3 of sal ammoniac in strong vinegar, or preferably in a vinegar made by adding pure acetic acid to distilled water. The articles to be bronzed are placed in a warm but moist chamber, and are repeatedly painted over with the solution, a soft brush or mop being used for the purpose. In the majority of the methods employed, the actual proportions of the ingredients are not stated, or when stated are not to be relied upon; in every case a trial should be made on clean pieces of copper, and repeated at least once. As a rule, it will be found that the sal ammoniac must be in excess of the other salts.

(b) Dissolve in 11 gal. of hydrochloric acid as much as possible of iron in fine wire or scales. When the liquid is saturated a deposit will form at the bottom. Then add 2·2 lb. of arsenious acid and stir vigorously. When the acid is dissolved, the bath is complete. The objects to be bronzed are connected to the negative pole of a battery, the opposite electrode being formed of rods or plates of retort carbon. Articles of copper or brass become black at once, but those of iron are attacked by the bath. It is therefore necessary to nickel the latter. In order to preserve the deposit of iron the surface must be lacquered.

Black Colour on Brass.—(1) The best means for producing a black surface on brass, pinchbeck, or silver, is said to be platinum chloride, which is allowed to liquefy by exposure to the air. It is rubbed in with the finger, or, best, with the ball of the thumb. After blacking, the object is washed and polished with oil and leather. Platinum chloride is dear, but a little of it will do a great deal of work.

(2) A solution of nitro-muriate of platinum will blacken brass quicker than anything else; but possibly 2 oz. corrosive sublimate dissolved in 1 qt. of vinegar will act quickly enough. This solution is brushed over the brass, allowed to remain till the latter is black; it is then wiped off, and the brass cleaned and black-leaded.

(3) If merely wanted to black it, brush on a mixture of best vegetable black and French polish. This will give a nice dead black, or modify the deadness by the addition of polish.

(4) Make a strong solution of nitrate of silver in one dish, and of nitrate of copper in another. Mix the two together, and plunge the brass into the mixture. Remove and heat the brass evenly until the required degree of dead blackness is obtained.

Bronzing Gas-Fittings.—(a) Boil the work in strong lye, and scour it free from all grease or old lacquer; pickle it in diluted nitric acid till it is quite clean (not bright), then dip in strong acid, and rinse through four or five waters; repeat the dip, if necessary, till it is bright; next bind it very loose with some thin iron wire, and lay it in the strongest of the waters you have used for rinsing. This will deposit a coat of copper all over it, if the water or pickle be not too strong; if such is the case, the copper will only be deposited just round where the wire touches. When the copper is of sufficient thickness, wash it again through the waters, and dry it with a brush in some hot sawdust; box-dust is best, but if this is not at hand, oak, ash, or beech will do. It is now ready for bronzing. The bronze is a mixture of black-lead and red bronze,

varied according to shade required, mixed with boiling water. The work is to be painted over with this and dried, then brushed until it polishes. If there are any black spots or rings on the work, another coat of the bronze will remove them. Lacquer the work with pale lacquer, or but very slightly coloured, for if it is too deep, it will soon chip off.

Bronzing Electrotypes. *Green.* Steep the medal or figure in a strong solution of common salt or sugar, or sal ammoniac, for a few days, wash in water and allow to dry slowly, or suspend over a vessel containing a small quantity of bleaching powder, and cover over—the length of time it is allowed to remain will determine the depth of the colour.

Brown.—Four or five drops of nitric acid to a wine-glassful of water, and allowed to dry, and when dry impart to the object a gradual and equal heat; the surface will be darkened in proportion to the heat applied.

Black.—Wash the surface of the object over with a little sulphide of ammonium (dilute), and dry at a gentle heat; polish with a hard brush afterwards.

Bronzing Iron.—To 1 pint of methylated finish add 4 oz. of gum shellac and ½ oz. gum benzoin; put the bottle in a warm place, shaking it occasionally. When the gum is dissolved, let it stand in a cool place two or three days to settle, then gently pour off the clear liquid into another bottle, cork it well, and keep it for finest work. The sediment left in the first bottle, by adding a sufficient quantity of spirit to make it workable, will do for the first coat or coarser work when strained through a fine cloth. Next get ¼ lb. of finely-ground bronze green, the shade may be varied by using a little lampblack, red ochre, or yellow ochre; let the iron be clean and smooth, then take as much varnish as may be required, and add to the green colour in sufficient quantity; slightly warm the article to be bronzed, and with a soft brush lay a thick coat on it. When that is dry, if necessary lay another coat on, and repeat until well covered. Take a small quantity of the varnish and touch the prominent parts with it; before it is dry, with a dry pencil lay on a small quantity of gold powder. Varnish over all.

Bronze-Coloured Coating of Oxide upon Iron.—By the following process iron articles, especially for artistical purposes, can be readily provided with a beautiful bronze-coloured coating of oxide, which is quite proof against the influence of moisture, and has the further advantage that every desired bronze colour can be produced in a simple manner. Free the articles from grease and, after polishing them, expose them to the vapours of a mixture of concentrated hydrochloric and nitric acid (1 : 1) for 2 to 5 minutes. Continue the heating until the bronze colour appears upon the articles. After thoroughly rubbing in with vaseline heat again until the vaseline begins to decompose. After cooling, the article is again thoroughly rubbed with vaseline. By exposing the iron articles to the vapours of a mixture of concentrated hydrochloric and nitric acid, light red brown shades are obtained. By adding, however, acetic acid to the mixture, and allowing the vapours to act upon the iron, coatings of oxide of a beautiful bronze yellow colour may be obtained. By various mixtures of acids, coatings of oxide of all possible shades, from dark to light red-brown from dark brown-yellow to light bronze yellow may be produced upon iron. In this manner 5-ft. long T bars for iron boxes have been coated with such layers of oxide, and though they were exposed for 10 months to the action of the air of a laboratory constantly filled with acid vapours they did not show the slightest alteration.

Bronzing of Tin.—Prepare first two solutions, one of 1 part ferrous sulphate (green vitriol), 1 part cupric sulphate (blue vitriol), and 20 parts of distilled water, and the other of 4 parts verdigris and 16 parts vinegar. Thoroughly clean the article by means of

a clean brush with a fine earth and water, and after thorough drying apply to both sides a light coat of the first solution by means of a brush. After drying, the article presents a blackish appearance. The second solution is then applied with a brush until the article acquires a dark copper-red colour. It is now allowed to dry 1 hour and then polished with a soft brush and finely elutriated bloodstone, the surface being frequently breathed upon so as to make the bloodstone adhere. It is finally polished with the brush alone, which is from time to time drawn over the palm of the hand. To protect the bronze against moisture, cover it with a very thin layer of gold lacquer.

To Bronze Zinc Fret Work.—Coat the metal with a very thin gold size, and when nearly dry rub on a sufficient quantity of red bronze (bronze powder), dry, and burnish.

(*c*) *Oxidising Copper and Brass.*—Make a solution of ½ lb. hyposulphite of soda and ½ lb. nitrate of iron in 1 qt. of water. Immerse the articles in this. The shade of oxidation will vary according to the length of time the goods are immersed, so that any degree may be obtained.

Colouring and Decorating.—Metals may be coloured quickly and cheaply by forming on their surface a coating of a thin film of a sulphide. In 5 minutes brass articles may be coated with any colour, varying from gold to copper-red, carmine, and dark red, and from light aniline blue to a blue-white, like sulphide of lead, and at last a reddish white, according to the thickness of the coat, which depends on the length of time the metal remains in the solution used. The colours possess a very good lustre, and if the articles to be coloured have been previously thoroughly cleaned by means of acids and alkalies, they adhere so firmly that they may be operated upon by the polishing steel. To prepare the solution, dissolve ½ oz. hyposulphite of soda in 1 lb. water, and add ½ oz. acetate of lead dissolved in ½ lb. water. When this clear solution is heated to 190° to 200° F. (88° to 93° C.), it decomposes slowly, and precipitates sulphide of lead in brown flakes. If metal be now present, a part of the sulphide of lead is deposited thereon, and according to the thickness of the deposited sulphide of lead the above colours are produced. To produce an even colouring, the articles must be evenly heated. Iron treated with this solution takes a steel-blue colour; zinc, a brown colour; in the case of copper objects, the first gold colour does not appear; lead and zinc are entirely indifferent. If, instead of the acetate of lead, an equal weight of sulphuric acid is added to the hyposulphite of soda, and the process carried on as before, the brass is covered with a very beautiful red, which is followed by a green (which is not in the first scale of colours mentioned above), and changes finally to a splendid brown with green and red iris glitter. This last is a very durable coating, and may find special attention in the manufactures, especially as some of the others are not very permanent. Very beautiful marble designs can be produced by using a lead solution thickened with gum tragacanth on brass which has been heated to 210° F. (99° C.), and is afterwards treated by the usual solution of sulphide of lead. It may be used several times.

Brass.—(1) An orange tint inclining to gold is produced by first polishing the brass and then plunging it for a few seconds in a warm neutral solution of crystallised acetate of copper. Dipping into a bath of copper, the resulting tint is a greyish green; while a beautiful violet is obtained by immersing the metal for an instant in a solution of chloride of antimony and rubbing it with a stick covered with cotton. During this operation the brass should be heated to a degree just tolerable to the touch. A *moiré* appearance, vastly superior to that usually seen, is produced by boiling the object in a solution of sulphate of copper. There are three methods of procuring a black

lacquer on the surface of brass. The first, which is often employed by instrument-makers, consists in polishing the object with tripoli, and washing it with a mixture composed of 1 part nitrate of tin, 2 parts chloride of gold. Allow this wash to remain for 15 minutes, then wipe it off with a linen cloth. An excess of acid increases the intensity of the tint. In the second method, copper turnings are dissolved in nitric acid until the latter is saturated; the objects are immersed in the solution, cleaned, and subsequently heated moderately over a charcoal fire. This process must be repeated in order to produce a black colour, as the first trial only gives a dark green. Finally, polish with olive-oil. The third method is done with chloride of platinum. In the United States and on the Continent much pains is taken to give objects "an English look." For this purpose they are first heated to redness, and then dipped in a weak solution of sulphuric acid. Afterwards they are immersed in dilute nitric acid, thoroughly washed in water, and dried in sawdust. To effect a uniformity in the colour, they are plunged in a bath consisting of 2 parts nitric acid and 1 rain-water, where they are suffered to remain for several minutes. Should the colour not be free from spots and patches, the operations must be repeated until the desired effect is produced. ('Eng. Mechan.')

To Produce a Silver-White Coating on Brass.—Dissolve 46 parts cream of tartar and 4 tartar emetic in 1000 hot water, add 50 hydrochloric acid, 125 powdered (or fine granulated) tin, and 30 powdered antimony (metal). Heat to boiling and dip into it the objects to be coated. After having been boiled half an hour the brass will have a silver-white, hard, and durable coating.

Various Colourings for Metals.—Royal red on copper articles. First clean and polish and dry thoroughly. Melt some saltpetre in an iron pan and immerse the article in this. This anneals the copper, and leaves a firm and thick scale. Next put the goods into a boiling solution made up of the following: alum, 12 oz.; acetate of copper, 7 oz.; sulphate of copper, 2 oz. water, 3½ gallons. This solution must be made and boiled in a copper vessel, and the articles left in it about 5 minutes. Finish by washing, drying and polishing.

Olive green on brass is obtained by the process just described for royal red on copper.

"Blue metal" finish on steel small goods. This is used for watch-cases, vesta-boxes and "fancy" goods. The goods are of steel with polished or very smooth clean surface. First submit them to the Bower-Barff process, the articles being made a red heat in a closed retort, into which live steam is then injected. This produces the black "gun metal" finish. The blue effect is obtained by immersing the goods into a mixture of 1 part of binoxide of manganese and 4 parts of nitrate of potassium. The two substances are melted in an iron crucible until ebullition (boiling) occurs, the articles (perfectly clean and dry) being then put in. They need only be in for a moment or two, being then taken out and plunged into paraffin oil. Final finishing is done with a fine satin-finishing steel scratch-brush.

Black "gun metal" finish to steel small goods. This is obtained by the Bower-Barff process as just described with "blue metal" finish.

Small Articles Different Colours.—(*a*) Small metallic articles, buttons, clasps, buckles, and others, have different coloured films produced on them by various methods. Rainbow colours are produced on brass buttons by stringing them on a copper wire and dipping them in a bath of plumbate of soda freshly prepared by boiling litharge in caustic soda, and pouring it into a porcelain dish. A linen bag of finely pulverised litharge or hydrated oxide of lead is suspended in the solution, so as to keep up the original strength of the solution. While the buttons are in the solution, they are touched one after the other with a

platinum wire connected with the positive pole of a battery, until the desired colour appears. The galvanic current employed must not be too strong. The colours are more brilliant if they are heated after they have been rinsed and dried. Coloured films are more conveniently produced upon bright brass by different chemicals, by painting with them, or by immersion. For example: Golden yellow.—By dipping in a perfectly neutral solution of acetate of copper. Dull greyish green.—Repeatedly painting with very dilute solution of chloride of copper. Purple.—Heating them, and rubbing over with a tuft of cotton saturated with chloride of antimony. Golden red.—A paste of four parts of prepared chalk and mosaic gold.

(*b*) In recent times small articles are also roughened by dipping in strong nitric acid, and, after washing and drying, they are coated with a rapidly drying alcohol varnish that has been coloured yellow with picric acid, red with fuchsine, purple with methyl violet, or dark blue with an aniline blue. This gives the desired colour with a beautiful metallic lustre. These colours are not very durable and are for inferior goods.

Colouring Bronze. — As to the colouring which may be given to bronze and which is obtained by various methods of oxidation, the following are some of the methods in vogue:—

(1) The dull colour of medal bronze is obtained by rubbing with a mixture of red ochre and black lead applied by a brush.

(2) The antique green is obtained by washing the metal in a liquid made of 10 gr. marine salt, the same quantity of cream of tartar and acetate of copper, the whole dissolved in 200 gr. vinegar and 30 gr. carbonate of soda.

(3) The Florentine is obtained by means of green vitriol (sulphate of iron), and then rubbing with wax.

(4) The citron tint is obtained by means of red ochre mixed with lampblack and oil.

(5) The old green bronze is obtained by several dippings in acid, and subsequently with wax.

(6) Verdigris is obtained by means of sal ammoniac, and wax afterwards.

(7) The smoke-tint is produced by annealing the object in a wisp of hay or straw, which is set on fire, and the article is burnished, so that the oxide formed may penetrate the metal. The smoke of turf may be used instead, waxing afterwards, and removing the grease by turpentine so as to carry off the uneven first layer.

(8) Dark or Berlin Bronze. Cleanse the metal by dipping it first momentarily in nitric acid, then rinsing quickly in running water, and rubbing with sawdust. The bronzing dip may be prepared by dissolving in 1 gal. hot water ½ lb. each perchloride of iron and perchloride of copper. The metal should not be allowed to remain in this dip any longer than is necessary to produce the desired colour. Rinse well, dry, and polish in warm sawdust or with a rag buff.

(9) In preparing bronze medals for the Melbourne Exhibition, a rich chocolate colour was obtained by the addition of a little copper acetate, mixed with an alkaline sulphide, to the ordinary colcothar bronzing powder, by which a film of mixed copper sulphide and oxide, somewhat resembling Chinese bronze, was produced.

Copper Articles, Red Stain for.—A brown colour may be produced upon copper articles by placing them in a bath composed of 1 part verdigris and 16 parts water, and compounded with ammonia until a clear blue solution is formed. To this bath add further a mixture of two parts liver of sulphur, 3 parts spirit of sal ammoniac, and 10 parts water shaking the mixture thoroughly before use. To avoid the formation of spots and stains, the articles must previously be thoroughly cleansed. By slight heating the colour passes into reddish-brown and becomes lighter.

Gold.—(1) Gold alloys, particularly those containing copper, acquire, through repeated heatings during their

manufacture, an unseemly brown or brownish-black colour, caused by the oxide of copper, to remove which they are boiled or pickled in very dilute sulphuric or hydrochloric acid, according to the colour they are to have. If we have an alloy containing only gold and copper, either sulphuric or hydrochloric acid is employed, for gold is not attacked by either of them, while the oxide of copper dissolves so easily that after the pickling the articles have the colour of pure gold, for the surface is covered with a thin film of gold. If the alloy consists solely of gold and silver, the liquid employed is nitric acid, and the articles are left in it a very short time; the acid dissolves a small quantity of silver, and the articles acquire the colour of gold. If the alloy contains both copper and silver, besides the gold, the method of pickling can be varied to suit the colour it is desired to give to it. If, for instance, it is put in sulphuric acid, the copper alone is dissolved, and the colour obtained is that of an alloy of gold and silver, for the surface consists of the two. If nitric acid were used, both copper and silver would be dissolved, and in this case the colour obtained would be that of pure gold. The articles are gently heated and allowed to cool again before boiling. The object of the heating is to destroy any grease or dust that adheres to them. If they are soldered with soft solder, they cannot of course be heated, and must be cleansed from grease and dust by first putting them in a strong lye, then washing with water and putting them in the acid. The acids are used dilute, usually in the proportion of 1 part concentrated acid to 40 of water. The articles are laid side by side in a porcelain or earthenware dish, and the dilute acid poured over them. From time to time one is taken out to see if it is yellow enough. When the proper colour has been reached, they are washed in clean water and dried. While this pickling is merely to bring out the colour of the gold, the colouring of gold has for its object the imparting to inferior goods the appearance of fine gold. Different mixtures can be employed for colouring gold, two of which are given below as affording very good results. Mix together 2 parts saltpetre, 1 of table salt, and 6 of alum, with 6¼ of water, and warm the mixture in a porcelain vessel. As soon as it begins to rise, add 1 part hydrochloric acid, and bring the contents of the vessel to a boil, stirring in the meantime with a glass rod. The articles to be coloured, suspended on hooks made of strong platinum wire or of glass, are first dipped in sulphuric acid and then put in the slowly cooking solution last described, and moved to and fro in it. In about 3 minutes they are taken out and dipped into a large vessel of water so as to see what colour they are. If the desired shade is not yet attained, they are dipped in again as often as necessary until they have it. In the subsequent dippings they are only left in the liquid for 1 minute. Articles coloured in this way have a light yellow colour, but matted appearance. They are repeatedly washed in water to remove the last trace of the liquid, and then dried in soft sawdust that has been warmed. Instead of drying in sawdust they can be dipped in hot water the last time and left in there a few seconds, and when taken out the water that hangs on them will evaporate almost instantly. The second method of colouring gold alloys is by means of a mixture of 115 parts white table salt, and 230 of nitric acid, with enough water added to dissolve the salt. This is boiled down to a dry mass of salt. The salt is put in a porcelain dish, and 172 parts fuming hydrochloric acid poured over it and heated to boiling. As soon as the suffocating odour of chlorine is perceived, the articles to be coloured are dipped in and the first time they are left 8 minutes in the liquid. In other respects the treatment is the same as above described. Articles polished previously do not require polishing again. Care must be taken not to inhale the dangerous gas; the opera-

tion must be conducted under a draught or out of doors. (Schlosser.)

(2) Place 4 oz. saltpetre, 2 oz. common salt, and 2 oz. alum in a plumbago crucible. Add sufficient water to cover the mixed salts. Now place the crucible on the fire, and allow the mixture to boil. When this takes place, place the article to be coloured in the mixture, taking care that it is suspended by a hair. It may be left in the crucible for about 15 minutes, when it should be withdrawn, washed in warm water, well brushed with beer and a fine scratch brush, and re-dipped, if the colour is not intense enough.

(3) For small gold articles, such as a keeper or plain ring, etc., a very good plan is to place them on a lump of charcoal and make them red-hot under the blow-pipe flame, and then to throw them into a pickle composed of about 35 drops strong sulphuric acid to 1 oz. water, allowing the articles to remain therein until the colour is sufficiently enhanced. Washing the article in warm water in which a little potash has been dissolved, using a brush, and finally rinsing and drying in boxwood sawdust, completes the operation.

(4) Another colouring mixture, which has been greatly recommended, consists of a mixture of 20 gr. sulphate of copper, 40 gr. French verdigris, 40 gr. sal ammoniac, and 40 gr. saltpetre, dissolved in 1 oz. glacial acetic acid. The articles, suspended by a horse-hair as before, are to be immersed in this mixture, withdrawn, and heated on a piece of copper until black. They are then to be placed in a pickle of equal parts oil of vitriol and water, which removes the black coating and brings up the colour. Washing in weak potash-water, rinsing and drying as before, terminates the treatment.

(5) An Indian native method.—Clean the article thoroughly by washing in hot soap and water, taking care to get rid of all greasiness and of all the soap. The natives use tamarind-water and also the soap-nut. Prepare a paste of the consistence of soft butter by mixing the following ingredients with *quantum suf.* of pure water—viz. 1 oz. saltpetre, 1 oz. crude sal-ammoniac, 2 oz. sulphate of copper; grind each separately to a fine powder, then mix with water and form the paste. Apply this paste pretty thickly and evenly over the article to be coloured, and place while wet on ignited charcoal; warm till it *dries* and *smokes*; then immediately dip into cold water, and clean by using tamarind-water and a soft brush. If the colour is not deep enough, repeat the process. Plunge the article whether of pure gold, alloyed gold, or gilt, into the following solution, and afterwards clean thoroughly with a soft brush and soap and water. To increase the depth of colour plunge 4 or 5 times, cleaning after each plunge: powder finely 2 oz. alum, 2 oz. saltpetre, ½ oz. sal-enixum (the refuse from aquafortis), put all into an earthenware pipkin, with 5 oz. water, *warm* over the fire, add 1 oz. gilders' wax, and gently simmer for a short time. To be used when nearly cold.

(6) This amplifies (2). Jewellery to be coloured should be at least 15 carats fine, and the solder should be only a shade under that. There must be no pewter or silver solder on it. It should just be annealed, and pickled in water to which sufficient sulphuric acid has been added to render it sharply acid to the taste. The best vessel to use for colouring is an ordinary clay crucible; the colouring mixture is composed of 2 oz. best saltpetre, 1 oz. alum, and 1 oz. common salt. These are placed in the crucible with sufficient water to moisten them, and when they are melted, place the gold articles in the mixture. The jewellery must be strung on a piece of wire. It is better to keep a piece of platinum for this purpose, which should be annealed each time before use; failing that, a piece of gold wire (15 carat). You may use silver wire, but nothing baser. The colouring composition dissolves the silver, so you will require a fresh piece occasionally. You must move them about at intervals in the crucible, and

as the composition gets thick add a very little hot water from time to time. It must not be made too thin, but just sufficiently liquid to boil. The goods require to be in almost continual motion, or they will stick to the bottom of the crucible. Should this untoward (and in the hands of a novice far from unlikely) event happen, don't attempt to pull them out by force, but boil them out with hot water. After they have been in the crucible for a few minutes, take them out and examine them; but whenever they are taken out they must be plunged at once into boiling water, or the composition will dry on them, and you will have some difficulty in removing it. They should now be scratch-brushed and returned to the crucible. From 10 to 20 minutes will be sufficient. When they are coloured, take them out, scratch-brush, wash in clean hot water, and dry in boxwood sawdust. This process acts by dissolving away the alloy, and leaving only the pure gold on the surface. If the goods are anything less than 15 carat gold, they must be electro-gilt.

Iron and Steel.—Damascening. By damascened steel is meant that sort of steel which receives shades of darker and lighter colour after the surface has been corroded with acids: it is remarkable, when genuine, for its elasticity, strength, and homogeneous fracture when broken.

(*a*) Natural Damascus steel comes from India and Persia, is distinguished by its excellent quality and mixed veining, and is worked up principally into sword blades. These Oriental blades consist of a more highly carburetted steel than any European manufacture seems to possess, and in which, by skilful cooling, a division of 2 different carburets has taken place. This separation is clearly visible on corrosion with acids, as the parts subjected to the action of the acid are deepened and dyed by the exposure of the carbon, and, with the other less affected and consequently brighter parts, produce a design, more or less delicate, of grey and white lines, which often have a certain degree of regularity. A distinction is made between parallel striping or waving lines and mosaic damascening. If the cast steel is made in iron moulds, as usual, the above separations do not take place. By re-welding and sudden cooling, the Damascus steel loses its pattern. The Indian Woolz, as especially used for sword-blades, contains foreign substances mixed with it—as nickel, tungstate of iron, or manganese—which are said to impart peculiar value. Few European smiths succeed in working up Indian steel, because they do not accurately know the temperature required for its treatment. In consequence of the large amount of carbon it contains (7·18 per cent.), this can only be effected within certain climatic limits: if too high a temperature is exhibited, it breaks to pieces under the hammer; if too low, it assumes a hard and brittle character. The iron appears disposed to receive a considerable quantity of carbon, through the manganese combination.

(*b*) Artificial damascened steel. Attempts have been made, with more or less success, to imitate the real damascening, and the following methods have been suggested:—

Luynes imitated the Indian process; smelting soft iron with charcoal, tungstate of iron, nickel, and manganese, was highly successful. The manganese, more especially, produced damascened steel, and introduced a large quantity of carbon without injuring its malleability.

Bréant produces a most valuable damask, very closely resembling the real, by smelting 100 parts iron with 2 of lampblack, or by smelting cast-iron with oxidised iron filings.

Clouet, Hachette, and Mille smelt iron plates of different natures, harder and softer, together, and produce a damask remarkable for its elasticity and hardness, but not having the wavy damascening of the real blades.

(3) Brown Coats.—All browning methods known at present, obtained

by moistening iron with acid, copper, or iron solutions, permitting them to dry in air, brushing off the rust formed in this manner, and repeating the operation several times, only produce a more or less light or dark red-brown rust coating upon iron articles. Barff's process, as well as that of heating iron articles in superheated aqueous vapour, only causes an iron protoxide layer upon iron. These last-mentioned two methods have the further defect that the protoxide of iron layer peels off in a short time, whereby rust is invited. Iron articles are easily coppered or brassed by dipping in copper solutions, or coppered or brassed by the galvanic method; these coatings also scale off after a short time, especially if the iron surface was not thoroughly cleaned, when exposed to the influence of moist air.

By the following process, it is easy to provide iron articles with a handsome bronze-coloured protoxide coating; it resists the influence of humidity pretty well, and besides this, the operator has it in his power to produce any desired bronze colour in a simple manner. The cleansed and scoured articles are exposed to the vapours of a heated mixture of concentrated hydrochloric and nitric acids (1 and 1) for 2 to 5 minutes; and then, without unnecessarily touching them, heated to a temperature of 572° to 662° F. (300° to 350° C.). The heating is continued until the bronze colour becomes visible upon the articles. After they have been cooled, they are rubbed over with petroleum jelly, and again heated until the jelly begins to decompose. After cooling, the article is anew rubbed over with petroleum jelly. If now the vapours from a mixture of concentrated hydrochloric and nitric acids are permitted to operate upon the iron article, light red-brown tones are obtained. However, if acetic acid is mixed with the before-mentioned acids, and the vapours are permitted to operate upon the iron, oxide coatings are obtained possessing a handsome bronze-yellow colour. All gradations of colours from dark red-brown to light red-brown, or from light bronze-yellow to dark brown-yellow, are produced by varying the mixtures of the acids. T-rods, 4½ ft. long, for iron boxes, coated with such oxide layers, after 10 months, during which time they were continuously exposed to the influence of the air of a laboratory constantly laden with acid vapours, do not betray the slightest traces of change. (Prof. Oser, 'Ding. Pol. Jl.')

(4) Dissolve in 4 parts water, 2 of crystallised iron chloride, 2 of antimony chloride, and 1 of gallic acid, and apply the solution with a sponge or cloth to the article, and dry it in the air. Repeat this any number of times, according to the depth of colour which it is desired to produce. Wash with water, and dry, and finally rub the articles over with boiled linseed-oil. The metal thus receives a brown tint, and resists moisture. The antimony chloride should be as little acid as possible.

(5) *To Colour Iron.*—1. By placing bright articles of iron in a mixture of a solution of 4 oz. 15 dr. of sodium hyposulphite in 1 qt. of water, and one of 1 oz. 3 dr. of acetate of lead in 1 qt. of water, and heating gradually to boiling, they acquire an appearance as if blued. 2. By bringing a mixture of 3 parts of sodium hyposulphite and 1 part of acetate of lead in a dissolved state upon bright iron surfaces and heating, a layer of disulphide of iron is deposited, through which shows the metallic surface in various shades of colour. 3. By dipping small articles of cast or wrought iron in melted sulphur, to which some soot has been added, a coating of ferric sulphide is formed which acquires a beautiful polish by rubbing.

(6) *To Blue Small Sheet-Steel Articles.*—Dip the articles into a fluid alloy of 25 parts lead and 1 tin, which melts at the degree of heat required for bluing. The dipping can also be done in a sand-bath heated to and kept at the temperature required

(572° F. for dark blue, and 478° F. for pale blue).

Medals.—This operation is to give to new metallic objects the appearance of old ones, by imitating the characteristic appearance imparted by age and atmospheric influences to the metals or metallic compounds, and especially to copper and its alloys.

(*a*) The most simple bronze is obtained by applying upon the cleansed object a thin paste made of water with equal parts of plumbago and iron peroxide, with a certain proportion of clay. Then heat the whole, and when the object is quite cold, brush in every direction for a long time with a middling stiff brush, which is frequently rubbed upon a block of yellow wax, and afterwards upon the mixture of plumbago and iron peroxide. This process gives a very bright red bronze, suitable for medals kept in a show case.

(*b*) This bronze may also be produced by dipping the article into a mixture of equal parts of perchloride and nitrate of sesquioxide of iron, and heating until these salts are quite dry. Then rub with the waxed brush as described.

(*c*) Cleanse the article, and cover it with ammonia hydrosulphate, which allow to dry, then brush with iron peroxide and plumbago, and afterwards with the waxed brush. If the piece impregnated with ammonia hydrosulphate is gently heated a black bronze is obtained, which being uncovered at certain places produces a good effect.

Silver.—(1) Silver which has become much tarnished may be restored by immersing in a warm solution of 1 part cyanide of potassium to 8 of water. (This mixture is extremely poisonous.) Washing well with water, and drying, will produce a somewhat dead-white appearance, which may be quickly changed to a brilliant lustre by polishing with a soft leather and rouge.

(2) Have ready a basin containing equal parts vitriol and water, make the article white in a gas flame (not white heat, but a snowy white, which it will assume after exposure to the flame), then plunge it into the pickle, and there leave it for ½ hour, then dry in boxwood sawdust.

(3) Heat to a dull red (if there is no lead present), allow to cool, and when cold boil in a pickle of water acidulated with sulphuric acid (30 water, 1 acid) until perfectly white; take out, swill in clean water, and burnish the prominent parts; dry in hot boxwood sawdust.

(4) A simple way—but not half so good—is to brush up with whiting moistened with turpentine, and then wash out in clean hot water, and dry in the sawdust.

Tin.—(*a*) Crystallised tin-plate has a variegated primrose appearance, produced upon the surface of tin-plate, by applying to it in a heated state some dilute nitro-muriatic acid for a few seconds, then washing it with water, drying, and coating it with lacquer. The figures are more or less diversified, according to the degree of heat, and relative dilution of the acid. Place the tin-plate, slightly heated, over a tub of water, and rub its surface with a sponge dipped in a liquor composed of 4 parts aquafortis, and 2 distilled water, holding 1 of common salt or sal ammoniac in solution. When the crystalline spangles seem to be thoroughly brought out, the plate must be immersed in water, washed either with a feather or a little cotton, taking care not to rub off the film of tin that forms the feathering, forthwith dried with a low heat, and coated with a lacquer varnish, otherwise it loses its lustre in the air. If the whole surface is not plunged at once in cold water, but is partially cooled by sprinkling water on it, the crystallisation will be finely variegated with large and small figures. Similar results will be obtained by blowing cold air through a pipe on the tinned surface, while it is just passing from the fused to the solid state.

(*b*) To give crystalline appearance to tinned plates, take a sheet of tin, and cleanse it from all grease by rubbing over it 1 part of whiting and 1 part of magnesia. Afterwards place

the sheet of tin on a plate of iron in an urn or muffle, and heat it to straw colour; then dip it into the following solution for one instant:—

Water	14 lb.
Nitric acid (chemically pure)	3 lb.
Hydrochloric acid . .	4 lb.
Bichromate of potash .	2 oz.

Then wash in warm water made slightly alkaline by adding 1 oz. of soda to 1 gal. of water. These sheets of tin can be made any colour—gold, crimson, green, etc.—by coating them with coloured lacquers.

Zinc.—(*a*) Puscher employs acetate of lead for this purpose. On applying this substance, mixed with a minium preparation, a reddish-brown tinge is obtained. The cupola of the synagogue at Nuremberg was thus coloured, as an experiment, and to all appearance is yet unaffected by the weather. By adding other bases, lighter or darker tints of grey and yellow may be obtained, giving the zinc-work the appearance of carved stone. With a solution of chlorate of copper, the preparation turns the sheets of zinc black. ('Iron.')

(*b*) A beautiful and permanent dark or light green coating, resembling enamel, can be applied to all kinds of zinc articles, especially those made of sheet zinc, in the following manner: 5 oz. soda hyposulphite are dissolved in 50 oz. boiling water, and the solution is poured at once, in a fine stream, into 2½ oz. strong sulphuric acid. The milk of sulphur that separates will soon ball together in lumps and settle. The hot liquid containing soda sulphate and sulphuric acid is decanted, and the cleansed zinc is put into it. In a short time it will acquire a very brilliant light-green coating of sulphide, and only needs to be washed and dried. By exposing it repeatedly and for a longer time to this hot bath, the coating grows thicker and the colour darker and more brilliant. The temperature must not fall below 145° F. (63° C.); when it does, the solution should be heated up to 190° F. (88° C.), to obtain a fine and brilliant deposit. By dipping these articles in dilute hydrochloric acid, 1 of acid to 3 of water, sulphuretted hydrogen is evolved, and this enamel-like coating loses its lustre, and gets lighter in colour. Aqueous solutions of aniline colours have little effect upon this dull surface, and none on the grey brilliant coating. The effect of marbling can be obtained by moistening the grey zinc and applying hydrochloric acid in spots with a sponge, then rinsing it off, and while still wet flowing over it an acidified solution of copper sulphate, which produces the appearance of black marble. As the zinc has generally a dull surface, it must receive a coat of copal varnish. If 1½ oz. chrome alum and 1½ oz. more soda hyposulphite be added to the solution, the article will have a brownish colour. (C. Puscher, 'Ding. Pol. Jl.')

Browning and Blacking Gun-barrels. *Browning.*—(*a*) Chloride of antimony has been much used for browning gun-barrels, is excellent in its operation, and has been called, in consequence, browning salt. It is mixed to a thin creamy consistence with olive-oil; the iron is slightly heated, dressed evenly upon its surface with this mixture, and left until the requisite degree of browning is produced. The sharpening of the chloride of antimony can be effected by adding a little nitric acid to the paste of olive-oil and chloride of antimony, so as to hasten the operation.

(*b*) Aquafortis, ½ oz.; sweet spirit of nitre, ½ oz.; spirit of wine, 1 oz.; blue vitriol, 2 oz.; tincture of chloride of iron, 1 oz.; water, 40 oz. Dissolve the blue vitriol in the water, then add the other materials, and the water is warmed to dissolve the blue vitriol; let it get cold before adding the other materials. The burnishing and marking can be effected with the burnisher and scratch-brush. The polishing is best effected by rubbing with a piece of smooth, hard wood, called polishing wood. It is lastly, varnished with

shellac varnish, and again polished with the hard wood polisher.

Some prefer the tone of brown produced by blue vitriol, 1 oz.; sweet spirit of nitre, 1 oz.; water, 20 oz.

In any case, the surface of the iron must be well cleaned, and rendered quite bright; it is then freed from grease by rubbing with whiting and water, or better, with powdered quicklime and water. The browning composition is then placed on, and allowed to remain 24 hours. It is then rubbed off with a stiff brush. If not sufficiently browned, repeat the last process after browning. Clean the surface well with hot water containing a little soda or potash, and, lastly, with boiling water, and dry it. The surface can be burnished and polished.

Varnish with tinsmith's lacquer, or with gum shellac, 2 oz.; dragon's blood, 3 dr.; methylated spirits of wine, 4 pints. The metal should be made hot before applying this varnish, and will present an excellent appearance. If the varnish is not required to colour, but only to preserve the actual tint produced on the metal surface by the browning fluid, leave out the dragon's blood.

(*c*) Mix 16 parts of sweet spirit of nitre, 12 parts of a solution of sulphate of iron, a like quantity of butter of antimony and 16 parts of sulphate of copper. Let the mixture stand in a well-corked bottle in a moderately warm place for 24 hours, then add 500 parts of rain-water and put it away for use.

After the barrel has been rubbed with emery paper and polished, wash it with fresh lime-water, dry thoroughly, and then coat it over uniformly with the above mixture; it is best to use a tuft of cotton. Let it dry for 24 hours, and then brush it with a scratch-brush. Repeat the coating and drying twice, but in rubbing off for the last time use leather moistened with olive-oil in place of the scratch-brush, and rub until a beautiful lustre is produced, then let it dry for 12 hours and repeat the polishing with sweet oil.

(*d*) Spirits of nitre, $\frac{3}{4}$ oz.; tincture of steel, $\frac{3}{4}$ oz.; or use the unmedicated tincture of iron if the tincture of steel, cannot be obtained; black brimstone, $\frac{1}{4}$ oz.; blue vitriol, $\frac{1}{2}$ oz.; corrosive sublimate, $\frac{1}{4}$ oz.; nitric acid, 1 dr.; copperas, $\frac{1}{4}$ oz.; mix with $1\frac{1}{2}$ pint rain water, and bottle for use. This is to be applied in the same manner as (*a*). It causes the twist of the barrel to be visible after application, a quality which the other liquid does not possess.

(*e*) 1. Blue vitriol, 4 oz.; tincture of muriate of iron, 2 oz.; water, 1 qt.; dissolve and add aquafortis and sweet spirits of nitre, of each, 1 oz. 2. Blue vitriol and sweet spirits of nitre, of each, 1 oz.; aquafortis, $\frac{1}{2}$ oz.; water, 1 pint. To be used in the same manner as (*a*).

(*f*) Wet a piece of rag with antimony chloride, dip it into olive-oil, and rub the barrel over. In 48 hours it will be covered with a fine coat of rust. Remove this with a scratch-brush, and apply oil.

Blacking.—2 oz. solution of nitric acid, 4 oz. tincture of steel, 3 oz. spirits of wine, 3 oz. sweet spirits of nitre, 1 oz. vitriol blue, $1\frac{1}{2}$ pint rain-water. Scour the barrel smooth; remove all grease with lime, then coat with the mixture freely with a piece of sponge, but not so as to run about the barrel. Let stand in a cool place for about 10 hours; then remove to a warm room, and let stand till dry, when the rust will fly off, and not be sticky or streaky. The barrels are not dry, and must stand until quite dry, or the result will be a red barrel. The scratching must be done with lard, then boil for about 10 minutes; take out and wipe inside and out; let stand till cool, then scratch to remove the dead rust; wipe with clean rag, then coat with the mixture lightly; let stand till dry. Scratch, boil, etc., as in first coat for 6 coats, when the barrels may be finished by oiling. If this process be carried out, the barrels will be as black as soot. The furniture should be polished as bright as possible, and blued in the second blue, which will be what gunsmiths call "blacking."

MIRRORS.

(*See also* SILVERING, ETC.)

THE old method of silvering glass, sometimes called the amalgamation method, scarcely needs description here, as it is not now practised. Its great drawback was the time taken (3 to 4 weeks for one piece of glass), otherwise the result has been satisfactory, and the process is a cheap and simple one.

The following is a description of this method. A sheet of tin-foil, a little larger than the glass to be silvered, is spread out on a silvering-table, made smooth by a brush being passed over it, then coated with mercury (quicksilver) by means of a brush. When the surface is uniformly coated, more quicksilver is added so as to make a depth of $\frac{1}{16}$ in. to $\frac{1}{4}$ in. on the foil. The coating of oxide that appears is removed with a wooden tool, leaving a brilliant surface. The piece of glass is pushed slowly forward from the side with the long edge forward, and just dipping below the surface of the mercury to exclude the air. This ensures contact between the glass and metal, producing a brilliant surface. The plate is now practically floating on a bed of quicksilver. The next thing to do is to carefully load the glass with weights, and then tilt the table a little, say 10° to 12°, and so cause excess mercury to flow away. Day by day the mirror is tilted a little more until it is upright. In the course of 3 or 4 weeks the glass has a dry, permanent coating of tin amalgam. The method has objections besides the time taken; the vapour of mercury is poisonous, the loading of the glass, unless very nicely done, occasionally results in a fracture. The coating, too, is liable to crystallisation, and is rather easily damaged.

The following methods are quicker and based on the use of nitrate of silver.

Silvering Solutions.—(*a*) Dissolve 120 gr. of silver nitrate in 2 oz. distilled water, and pour this solution quickly into a boiling solution of 96 gr. of Rochelle salt in about 2 oz. of water. When cool, filter and make up to 24 fl. oz. with distilled water. Now make a separate solution of 120 gr. of silver nitrate in 2 oz. of distilled water, and add ammonia until the precipitate is nearly re-dissolved. Make up to 24 fl. oz. with distilled water. For use mix equal quantities of these two solutions just before the silvering is to be done.

(*b*) Dissolve 96 gr. of silver nitrate in 2 oz. distilled water, and add ammonia until the precipitate is nearly dissolved; filter and make up to 24 fl. dr. with distilled water. Now make a separate solution of 24 gr. of Rochelle salt in 2 oz. distilled water; boil this, and while boiling add 4 gr. of nitrate of silver previously dissolved in 2 dr. of water. When cool, filter and make up to 24 fl. dr. For use mix equal quantities of the two solutions just before the silvering is to be done.

Silvering Glass.—(*c*) 10 gr. pure silver nitrate to 1 oz. distilled water; add carefully, drop by drop, strong ammonia, until the brown precipitate is redissolved. When adding the ammonia, keep stirring with a glass rod. In another bottle make a solution of 10 gr. pure crystallised Rochelle salt to 1 oz. distilled water; then, when you have all ready, pour on sufficient to cover all the glass, using two-thirds of the silver solution, and one-third of the Rochelle salt. The mirror can be prepared well by cleaning it with a little wet rouge, and polished dry with a wash-leather; then warm the glass before the fire, or by letting it lie in the sun, to about 70-80° F. Pour on the solution as described above, and let it stand in the warm sunshine $\frac{1}{2}$-1 hour. When silvered, pour on it some clean soft or distilled water, and, while still wet, wipe it very gently all over with a little soft wadding, wet; this will take off all the roughness, so that it will take but little rubbing with the rouge leather to polish it. When per-

fectly dry, it is easily rubbed up to an exquisite polish.

(d) *Cheap Looking-Glasses.*—Place a sheet of glass, previously washed clean with water, on a table, and rub the whole surface with a rubber of cotton, wetted with distilled water, and afterwards with a solution of Rochelle salts in distilled water, 1 of salt to 200 of water. Then take a solution, previously prepared by adding silver nitrate to ammonia of commerce; the silver being gradually added until a brown precipitate commences to be produced; the solution is then filtered. For each square yard of glass take as much of the above solution as contains 20 grm. (about 309 gr.) silver, and to this add as much of a solution of Rochelle salt as contains 14 grm. salt, and the strength of the latter solution should be so adjusted to that of the silver solution that the total weight of the mixture above mentioned may be 60 grm. In a minute or two after the mixture is made it becomes turbid, and it is then immediately to be poured over the surface of the glass, which has previously been placed on a perfectly horizontal table, but the plate is blocked up at one end, to give it an inclination about 1 in 40; the liquid is then poured on in such a manner as to distribute it over the whole surface without allowing it to escape at the edges. When this is effected, the plate is placed in a horizontal position at a temperature of about 68° F. The silver will begin to appear in about 2 minutes, and in 20–30 minutes sufficient silver will be deposited. The mixture is then poured off the plate, and the silver it contains is afterwards recovered. The surface is then washed four or five times, and the plate is set up to dry. When dry, the plate is varnished, by pouring over it a varnish composed by gum dammar, 20 parts; asphalt or bitumen, 5; gutta-percha, 5; and benzine, 75. This varnish will set hard on the glass, and the plate is then ready for use.

(e) The following is a successful method for the inexperienced, and produces a fixed hard film of good density. Get three open glass jars or tumblers and chemically cleanse them with nitric acid. Dissolve 180 gr. of nitrate of silver in 3 oz. of distilled water in one of the tumblers. (When dissolved take ½ oz. of this solution, and put it aside in another jar or bottle, this also being chemically clean.) In another of the tumblers dissolve 150 grm. of caustic potash (pure by alcohol) in 2½ oz. distilled water.* In the third tumbler dissolve 75 gr. of chemically pure glucose in 2½ oz. of water. Now take the first tumbler with the silver solution in it and drop some pure ammonia into it until the solution becomes a muddy-brown colour. Continue dropping the ammonia until the solution becomes clear again and looks as it was before the ammonia was added. Now take the separate ½ oz. of silver solution, and drop some of this in the ammoniated solution drop by drop the same as the ammonia was added. This will make the solution muddy again, more yellow than brown. Use care with the silver solution, as any spilled on the hands will remove the skin. Now add the potash solution, and the mixture will go blackish. After this continue dropping ammonia in, stirring with a glass rod all the time, until the solution begins to clear again. It will not get as clear as before as there will be numberless black particles. Filter the solution by pouring it through a funnel in which is a plug of cotton wool or a filter paper. Now add more of the spare silver solution, drop by drop, stirring all the time, until a very faint precipitate again occurs, then immediately stop dropping the solution. Prepare the silvering dish, set it level and pour the solution in. Add sufficient distilled water to make it the right height in the dish. Pour the glucose solution in, and stir together. Immerse the surface of the mirror glass gently, holding it slanting as it is lowered in

* Ordinary water must never be used in silvering; it must always be distilled water.

so that air-bubbles will not be held under. By the time the glass is in position the solution will be a pale reddish purple colour, and will grow darker. A fine deposit of silver will soon come, and will be complete in from 10 to 20 minutes. Well wash the mirror with water, and place on edge to dry. The film can be polished with fine wash-leather over a pad of cotton-wool for about 15 minutes. The polishing must be gently done.

(*f*) Drayton's process.—(This may be considered as the earliest of the nitrate of silver methods.) A mixture is made of 1 oz. coarsely pulverised silver nitrate, ½ oz. spirits of hartshorn and 2 oz. water, which, after standing for 24 hours, is filtered, the deposit upon the filter, which is silver, being preserved, and an addition is made thereto of 3 oz. spirits of wine, at 60° above proof, or naphtha; 20–30 drops oil of cassia are then added; and, after remaining for about 6 hours longer, the solution is ready for use. The glass to be silvered with this solution must have a clean and polished surface; it is to be placed in a horizontal position, and a wall of putty or other suitable material is formed around it, so that the solution may cover the surface of the glass to the depth of ⅛-¼ in. After the solution has been poured on the glass, 6–12 drops of a mixture of oil of cloves and spirits of wine in the proportion of 1 part, by measure, oil of cloves to 3 of spirits of wine, are dropped into it at different places; or the diluted oil of cloves may be mixed with the solution before it is poured upon the glass; the more oil of cloves used, the more rapid will be the deposition of the silver; but the operation should occupy about 2 hours. When the required deposit has been obtained, the solution is poured off, and as soon as the silver on the glass is perfectly dry, it is varnished with a composition formed by melting together equal quantities of beeswax and tallow. The solution, after being poured off, is allowed to stand for 3–4 days in a close vessel, as it still contains silver, and may be again employed after filtration and the addition of a sufficient quantity of fresh ingredients to supply the place of those which have been used. About 18 gr. silver nitrate are used for each square foot of glass; but the quantity of spirit varies somewhat, as its evaporation depends upon the temperature of the atmosphere, and the duration of the process. By the addition of a small quantity of oil of carraway or thyme, the colour of the silver may be varied. The oil of cassia purchased of different manufacturers varies in quality; therefore on being mixed with solution it must be filtered previous to use.

(*g*) On the whole, the Rochelle salt process is the most certain, as well as the simplest. The two solutions are made thus: Solution A—silver nitrate in crystals, 10 gr.; distilled water, 1 oz. Dissolve the crystals in the water, then add liquid ammonia drop by drop, until the grey precipitate is just re-dissolved. A few drops more of the silver solution are added, until there is a slight permanent precipitate, which does not re-dissolve. This solution is now filtered, and, if not required for immediate use, will keep for years. Perfect films have been produced with solution made nearly twenty years before. Solution B—Rochelle salt (potassio-tartrate of soda) dissolved in distilled water. In the original formula it was specified that crystals must be used, and the strength was 10 gr. to the oz.; but crystals of Rochelle salt are not easy to get, and I used to dissolve some of the ordinary powdered variety in water and recrystallise it; but I am now using 25 gr. of the powder instead, with perfect success and much less trouble. This solution does not keep more than a few days. The glass to be silvered is cleaned in the usual way with pure nitric acid—some of the acid being poured on its surface and well spread with a brush or mop made by tying some calico round the end of a rod or strip of glass, using plenty of

acid, and washing it off with a good stream of water from a tap, finishing with distilled water, and laying the glass face downwards in a dish of distilled water until everything else is ready. The dish in which the glass is to be silvered should be thoroughly cleaned and rinsed with distilled water, and should allow the mirror to lie face downwards with a depth of at least ½ in. between it and the bottom of the dish. The mirror may be supported on two small blocks of glass cemented by shellac to the bottom of the dish at the extremities of diameter, or the mirror may have a block of wood fixed on its back by pitch, and be suspended by strings. This should be done before cleaning, and the necessary quantity of bath solution ascertained. When all is ready equal parts of silver ammonio-nitrate (solution A), of Rochelle salt (solution B), and of distilled water are taken and mixed together, and the cleaned mirror is immersed in it. In a few minutes the solution will turn brown, then nearly black, and a silver film will be seen to form on the glass surface, and gradually spread over it. This takes place more rapidly if the solutions and mirror are all warmed to about 90° F., when the process will be completed in a few minutes; but with cold solutions, and leaving all at rest all night, you may get good, dense, brilliant films. When the silvering is completed, the glass is well washed with plenty of water, finishing with distilled water, and set on edge to dry, after which it is gently polished with wash-leather, and a little very fine rouge. (A. W. Blacklock.)

(k) Some additional hints which experience has shown to be necessary for complete success are as follows:—

One of the most essential preliminaries is to see that the mirror to be silvered is chemically clean. When pitching on the block for suspension in the silver fluid, in spite of every care, the front surface of the mirror is very liable to be stained by pitch on the fingers, or particles touching the glass, and no amount of washing by water, or even nitric acid, will thoroughly remove the stains. The mirror will be spotted and speckled, when silvered, and the failure disheartening. To avoid this, first sponge the surface to be silvered, and the edges of the mirror, with turpentine, then wash well with soap and water under a flowing tap, and, finally, sponge the surface with a solution of nitric acid, washing afterwards with pure water till every trace of acid is removed. The mirror will then be chemically clean.

Another fruitful source of failure arises from water dripping from the back and sides of the mirror into the silvering solution. To prevent this, when the mirror is chemically cleaned, place it at once, face downwards, into a dish of distilled water, which contains just so much as will completely cover the surface of the mirror, and come up one-third of its depth. Here leave it till the silvering solution is mixed, and everything is ready for immersion.

By this time the back of the mirror is dry, and so much of the edge as will, when the mirror is immersed, be above the solution. Thus the dripping will be avoided, and the mirror will take the silvering, pure and clean, all round the edges, as well as in the central zones.

Transfer the mirror from the distilled water as quickly as possible, taking care that it sinks to the proper depth in the silvering solution, and equally all round.

With respect to the strength of the solution in winter, it is better to make it (as far as silver is concerned) a little stronger than that given in the formula, and also, in cold weather, it will often take a much longer time than an hour to produce a satisfactory result. If taken out too soon, in cold weather, the coating will be so thin that it cannot be polished.

Have a large jug of water ready at hand, and wash immediately on removal from the solution; then under a tap for ¼ hour. If the process has been, as it ought to be, successful, the mirror may be polished, after 3–4 hours' drying in

a warm room; but it is better to defer the polishing till the next day to secure perfect dryness and firmness. (S. Mills.)

(*i*) Brashear's process.—(1) The most important thing is the sugar solution forming the reducing agent. This greatly improves by keeping—a solution that has been made some months being much more effective than a newly-made one. It is convenient to have always some Winchester quarts of it in stock for use. I have, for convenience, varied his proportions slightly, and thus give them, as I have found them work so well. For the sugar solution I add to 10 per cent. of loaf sugar, in distilled water, 10 per cent. alcohol and ½ per cent. nitric acid. Solutions of 10 per cent. silver nitrate and of caustic potash are separately prepared, the latter one as wanted. These, with sufficient ammonia and a very dilute solution of silver nitrate, and also a similar very dilute one of ammonia, are prepared, the latter in order to obtain that pale brown colour of the ammoniated solution of silver nitrate that is absolutely necessary to have before adding the reducing agent.

Having selected a suitable dish to contain the liquid, in which the mirror can be placed face downwards with about ¼-¾ in. of liquid underneath, find on the basis of 1 of silver-nitrate solution to 4 of the total required liquid the amount of silver solution needed; to this add ammonia till the first formed precipitate is dissolved, then add one half of this quantity of the potash solution (this is a variation from Mr. Brashear's formula that I have found works well), and again add ammonia till the mixed solution is quite clear, taking care to put in only sufficient ammonia for that purpose; then add the weak solution of silver nitrate till a clear brown colour is obtained; should this become a dark brown, some of the weak solution will bring it to a pale brown colour, which must persist if the solution is left standing some time.

The mirror, previously cleaned with nitric acid and distilled water, and suspended in the dish in distilled water of sufficient amount to make up on addition of the solutions the total liquid required, is lifted out, and the prepared solutions are mixed with the distilled water and an amount of the reducing solution equal to about one half that of the silver nitrate solution, more or less, as the temperature is under or over 60°F.; as soon as all is intimately mixed, the mirror is immersed with one movement, beginning by dipping the edge first and lowering so as to prevent any air-bubbles forming under the glass. In 3-5 minutes the silver begins to form on the mirror, the solution changing from pink to dark brown or black; the film thickens quickly and in 25-30 minutes sufficient silver is deposited. The mirror can then be washed and put to soak in distilled water for a few hours, then taken out and dried and polished in the usual way, that is, with a soft pad of clean chamois, and going all over the mirror with light strokes till the bloom is all removed and a fair polish is obtained, finishing with a very little of the finest washed rouge, quite dry, lightly dusted on the pad; it is very important to well consolidate the film of silver by the unrouged pad before using any polishing powder.

It is a very good plan for any one who is not in the habit of silvering, or to whom the process is strange, to try the proportions of the solutions on some small pieces of glass till a satisfactory proportion for the temperature (for that is the chief factor in varying the amount of reducing solution necessary) of the room in which he is working. The most important thing (after the solutions) is the proper cleansing of the glass, for on the proper preparation of the surface of the glass a very great deal depends.

As already stated, this process is used when the glass to be silvered can be suspended in the liquid: it is not suitable when we attempt to silver surfaces face upwards. The mud formed settles down and prevents any

proper deposition of silver; this was a source of considerable trouble, when it was required to silver the 3-ft. mirror, and a pneumatic arrangement was eventually made to hold the mirror by the back, so that it could be silvered face downwards, and up to that size the silvering could be managed.

The great size of the 5-ft. mirror and its enormous weight (over half a ton without the cell) made it dangerous to suspend it, and the question of silvering became a serious one. In making experiments, in order to get rid of the mud formed in the process last mentioned, it was found that by leaving out the potash the silver was deposited from a nearly clear liquid and no mud was formed, and the first 5-ft. mirror was very successfully silvered in this manner. The solutions of silver and sugar are used in the same proportions without potash, but it is found advisable to use a stronger total mixture. For subsequent silvering of the 5-ft. mirror the Rochelle salt process has been used, and this for the deposition of the silver on a surface face up seems to be the best, using if necessary two or more applications.

In preparing a large mirror for silvering in this manner it is necessary to form it into a dish by using a band of paraffined brown paper round the edge, standing up an inch or more all round, and mounting the mirror on a swinging support so that it can be tipped up to throw off the water or spent solutions; in the case of the 5-ft. mirror, when mounted on this machine, this tipping up could be done by the same arrangement used for placing the mirror vertical for testing.

The proportions of solutions used for the 5-ft. were for each application 3000 c.c. silver solution ammoniated as already described, and 500 c.c. Rochelle salt solution, with about 29,000 c.c. distilled water; this remained on the mirror 28 minutes; another similar application was left on for 30 minutes; after thorough washing, distilled water was left on for some hours, and the film was dried and polished.

A very fine film of silver was deposited on a 5-ft. mirror, using one application only of 4000 c.c. silver solution and 750 c.c. Rochelle salt solution —this after one year was found to be in a very good state indeed; this was on the first mirror which, from some defect in the glass could not be made into a good mirror. The disc of glass was returned to the makers to be replaced by another. I took this opportunity of removing and collecting the whole of the silver by dissolving it in nitric acid. The assay of the deposit gives a total weight of 26·5 gr. silver on a surface of 2800 sq. in.; in actual weight somewhere between that of a threepenny and fourpenny piece, not a large amount of the 400 grm. of the silver nitrate used in depositing the film. The actual waste need not be very much, as the silver chloride can be easily deposited by the addition of common salt to the spent solutions, and the silver thus recovered.

It will be seen that the various processes all have the ammoniated solution of silver nitrate, and only differ in the reducing agent. The preparation of this solution, in order to get the pale brown colour already spoken of, demands some care. If the solution is too strong, on the addition of ammonia, a very flocculent deposit is formed, difficult of re-solution. If after the solution is cleared by the addition of ammonia, a strong solution of silver nitrate is added to get this colour, this flocculent deposit occurs; but if the weak solution advised be used, there is no difficulty in getting the proper colour free from any deposit. This is important. A word of caution may not be out of place concerning the production sometimes of a fulminate of silver, recognised by its dark grey metallic lustre. This is extremely liable to explode with great violence on the contact of almost anything; a few drops of water once sufficed to explode some in a beaker and blew it to fragments. By using moderately dilute solutions this danger is obviated. My own experience is not singular in

this respect, for Mr. Brashear relates a similar occurrence.

The silver film is not always of the same quality, and experiments are needed to get more information as to what determines the greater density and coherence of some films over others. I have had surfaces of glass silvered experimentally where the film would not wash off with any amount of wet rubbing, these mostly on surfaces that had been silvered many times. Probably the glass in this case was in the best state to receive the new deposit; certainly the condition of the surface does affect the coherence of the silver as well as the amount of the deposit, as judged by the way in which certain parts on a mirror that has been incompletely cleaned show that the deposition has begun long before other parts, necessarily resulting in an unequal thickness of film. With the most careful cleaning of a mirror I have often found that the first application did not succeed, but the second on the surface just cleaned off with nitric acid was all right. The nature of the liquid other than distilled water last in contact with the surface of the mirror seems to be the determining thing. (Common.)

A mirror for optical use should be silvered *face down*, and not face up, as the looking-glass people do. The following is the method. Standard solutions of any quantity to the proportions of ½ oz. distilled water to 50 gr. of nitrate of silver and potash pure by alcohol, 50 gr. to ½ oz. distilled water. These are to be kept in separate bottles, with glass stoppers. Dissolve 1 lb. at a time, as they keep as long as you like. Keep in the dark and cool, and in *white* bottles. Reducing solution, 840 gr. of ordinary white loaf-sugar in distilled water, add ½ dr. of good nitric acid (or about 25 gr. by weight if it is pure), add 3 oz. of rectified spirits of wine, make up to 25 oz. This must be some days old before using—the older the better, and will keep well, if well corked. These are used in equal quantities of each. The rule as to strength is that for every quart the bath requires, use not less than 100 gr. of silver. That is, for a 6 in., say, a bath of a quart is usually needed, so that there is 1 in. of fluid under the face of the mirror, and to come up the edge, say, ¼ in. Thus, take an ounce each of the silver and potash, and 1 oz. of the reducing solution, and so on in proportion. If the glass is a large one, more than 1 in. of fluid is needed to enable the mirror to be lowered one edge first to exclude bubbles. Dip the mirror in at an angle, say, of about 20°, when the first or lower edge touches the fluid.

To prepare the mirror for silvering, dissolve in a phial a piece of rosin in turpentine; with this smear the back of mirror for about two-thirds of its diameter, dab it with the finger till it will not stick to finger. Have a strip of wood ready, and a block of the necessary thickness screwed into this (so that the glass is in the dish the required depth), and about two-thirds the size of glass—it may be round or square. Melt pitch in a ladle or saucepan and pour on back of glass a little larger than the block, about ½ in. thick, press down the block on it. When cold pour a few drops of nitric acid and as much water, with a mass of cotton-wool tied on a glass stirring rod, to be had of the chemists, clean the face, not letting the acid run down the edge if possible, as, if edge is rough, it takes a lot of washing and rubbing to get clear of all traces of the acid, and it will spoil the film at the edge. Wash off the acid, and use a drop or two of the potash solution on the surface, and a little water. Again wash off with plenty of water (ordinary water), and well wash and rub with a handful of cotton-wool the edge, squeezing out the water many times, filling it again, and making sure no trace of acid is on the edge. Suspend in any dish with water till the bath is ready.

Mixing the solutions: Into the amount of silver solution you intend using, drop ammonia liquid of 0·880 strength till the solution becomes clear.

Pour into it two-thirds of the quantity of potash solution; it will again turn turbid; *quickly* clear again by dropping in ammonia. When it *begins* to get clear go steady, and just clear it of *particles*. Should it persist in remaining slightly coloured, as it will if you are long about clearing the pot, don't go on adding same. So long as the *particles* are gone, now add the rest of the potash solution. It will probably not turn turbid again if you have managed it well. This is a most important part of preparing the solutions, and it is all the better if it remains clear, and it will now take very few drops of the silver solution added to produce the slightly turbid, coloured condition which will not dissolve after several minutes' stirring, which means there is a slight excess of undissolved silver, and this shows there is not an excess of ammonia, and this is desirable and is now ready thus far. Put to these mixed solutions of silver and potash, about two-thirds of the total quantity of water of the bath, and now get the sugar solution and make it the other third—that is, if the total quantity of the bath is previously found must be, say, 3 pt., make up the silver and potash mixture to 2 pt., and of the sugar solution make 1 pt. These are added together in the silvering-dish, and stirred with a glass rod. Let all bubbles be got rid of before putting in the mirror. Now lift mirror out of the other water, pour on a little distilled water, let it run off after mopping it about on the surface, tilt mirror and wipe the edge and back so that no water will drain down its edge into the bath. Dip the mirror down one edge first, and gently, though pretty quickly, bring down the other part, and any bubbles will be pressed before the advancing surface and go out at edge. If you allow water to remain on the edge or back of glass, it will run off as you put it in and cause bubbles. It is best to silver in a moderate temperature—60° F. is a good one. In cold air it works very slowly. If it is intended to silver in a warm room, and the water and solutions are kept in a cold place, bring them all into the warmer room the night before. Then, perhaps, the washing water may be colder than the distilled water and the solutions. In that case make the water in which the mirror is suspended while getting ready a little warmer than the room. Wash with water a little colder rather than warmer than the bath; water warmer than bath, or mirror will dew it. Dry film by pressing several thicknesses of clean blotting-paper on it. Don't let paper move while on, then fan the surface, and it will be dry in a few minutes. Let the edge dry before polishing. Take out mirror when the bath is clear enough for you to see the edge of mirror as far as it is in the bath. No hurt to the silver if in longer than need, except that the silver gets whitened by the potash, and takes a little more time to polish. On adding the sugar the mixture begins to turn dark, and gets quite inky. As soon as the action is over, and silver all liberated and divided between the dish and the mirror, the bath begins to clear, and in time would become quite clear. Sometimes it will remain dark for a long time; but the above rule is the guide to take it out. For polishing, make a pad of wash-leather, brush it to remove any lime or grit, tie a lump of cotton-wool to form the pad, rub over its face the finest jeweller's rouge, and dust as much as you can out again, so that the pad is *merely soiled* while not charged with rouge. This will polish very many mirrors without recharging with rouge. First brush over the surface with a handful of clean cotton-wool before polishing, as also after.

There is no difficulty in getting the chemical good except the potash; but any chemist can get it for you from the makers. It must be pure by alcohol; if it turns any colour when dissolved it is no good; if it turns pale yellow, it is useless. The film will be thin and rotten, and will most likely come off while washing.

By just scraping away the pitch at one spot, and placing the point of a chisel between glass and the wood, and a tap on its end with a hammer, the block will fly off. If the glass is pitched to the strip of wood itself, there being no block, a tap on the end of the strip will separate the wood and the glass. Hold the glass on its edge, and scrape off pitch with a chisel. ('English Mechanic.')

(*j*) Professor Palmieri has devised a process for silvering glass by means of a reducing action on the salts of silver, which is said to have the advantage of producing a very brilliant metallic deposit. When into an ammoniacal solution of silver nitrate is poured, first a little caustic potash, and then a few drops of glycerine, the reduction begins at once; and this action is accelerated if ether or alcohol be added to the mixture. A moderate heat and darkness are said to increase the brilliancy of the precipitate, and darkness also favours the adhesion of the deposit to the mirror.

(*k*) Solution 1. Silver nitrate, 1 oz.; water, 10 oz. Solution 2. Caustic potash, 1 oz.; water, 10 oz. Solution 3. Glucose, ½ oz.; water, 10 oz.

The above quantities are those estimated for 250 sq. in. of surface. Add ammonia to solution No. 1 till the turbidity first produced is just cleared. Now add No. 2 solution, and again ammonia to clear; then a little solution, drop by drop, till the appearance is decidedly turbid again. Then add No. 3 solution, and apply to the clean glass surface. A film was obtained in 43 minutes at a temperature of 56° F. The plate of glass was rather large: 37 in. diameter and 4½ in. thick, and weighed 4 cwt. (A. A. Common.)

(*l*) Silvering Solution.—In 1 oz. distilled or pure rain water, dissolve 48 gr. crystallised silver nitrate. Precipitate by adding strongest water of ammonia, and continue to add the ammonia drop by drop, stirring the solution with a glass rod, until the brown precipitate is nearly, but not quite, redissolved. Filter, and add distilled water to make 12 fl. dr.

Reducing Solution.—Dissolve in 1 oz. distilled or very clean rain water, 12 gr. potassium and sodium tartrate (Rochelle or Seignette salts). Boil in a flask, and while boiling add 2 gr. crystallised silver nitrate dissolved in 1 dr. water. Continue the boiling 5–6 minutes. Let cool, filter, and add distilled water to make 12 fl. dr.

To Silver.—For a mirror 1¼–1½ in. diameter, take an ordinary 2 oz. graduated glass; procure a piece of thin

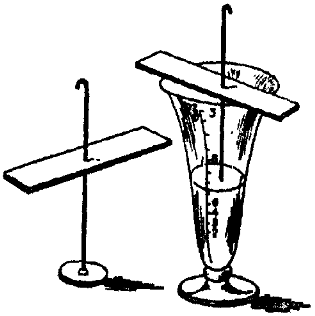

FIG. 41.

wood (cigar box will do) long enough to go across the top of it, and through the centre of the wood thrust, as shown in Fig. 41, a wire 7–8 in. long. After cleansing the glass to be silvered by immersing it in strong nitric acid, washing in liquor potassæ, and thoroughly rinsing with distilled water, with a bit of sealing wax attach one end of the wire to its face, as in Fig. 41. If the glass has had mercurial amalgam on it, it will probably be necessary to clean the back with rouge. On having this surface perfectly, chemically clean, depends in a great

measure the success of the operation.

Having attached the glass to the wire, lay the strip across the graduate, move the glass disc downwards until it nearly, but not quite, touches the sides of the graduate all round, taking care that its edges shall be as nearly level as possible. Having ascertained the height in the graduate at which the disc should stand, bend or clamp the wire so that it cannot slip. In the ordinary American graduate, with a mirror 1⅝ in. diameter, this will be at the 6 dr. mark, as nearly as may be. Remove the glass and pour into the graduate enough of equal quantities of the two solutions to fill the graduate exactly to the previously ascertained level. Stir the solutions so that they will become thoroughly mixed, and replace the disc to be silvered, taking great care that the surface to be silvered shall come in contact with the silvering fluid exactly at all points. The disc should be rinsed carefully before replacing, and should be put in while wet. Great care should be taken that no air-bubbles remain on the surface of the solution, or between it and the surface to be silvered.

Now set the graduate in the sun for a few minutes, if the weather be warm, or by the fire, if it be cold, as a temperature of 113°-122° F. is not conducive to the rapid deposition of a brilliant, firm, and even film of silver. The fluid in the sunlight soon becomes inky black, gradually clearing as the silver is reduced, until when exhausted it is perfectly clear. The mirror should be removed before this point is reached, as a process of bleaching sets up if left after the fluid is exhausted. From 20-80 minutes, according to the weather, purity of chemicals, etc., is required for the entire process.

When the mirror is removed from the bath, it should be carefully rinsed with distilled water from the wash bottle, and laid on its edge on blotting paper to dry. When perfectly dry, the back should be varnished with some elastic varnish and allowed to dry. The wire and sealing-wax can now be removed from the face, and the glass cleaned with a little pledget of cotton and a minute drop of nitric acid, taking great care that the acid does not get to the edges or under the varnish. Rinse, dry, and the mirror is finished.

The light reflected from a mirror made thus has somewhat of a yellowish tinge, but photometric experiments show that 25-30 per cent. more light is reflected than from the old mercurial mirrors. (Dr. James.)

(*m*) Large Mirrors for Photography. Dissolve 150 gr. silver nitrate in 6 oz. distilled water, and to this add ammonia, drop by drop, until the precipitate at first thrown down is redissolved. Now, having made a solution of caustic potash, in the proportion of 2¼ oz. to 50 oz. water, add 15 oz. of this to the above solution of silver; and add ammonia as before, until the deep brown precipitate again thrown down is redissolved. Now add 29 oz. distilled water, after which drop in some solution of silver nitrate, gently stirring all the while with a glass rod, until a precipitate begins to be formed. Previous to the immersion of the glass to be silvered, dissolve 1 oz. sugar of milk in 10 oz. water. This must be filtered and kept in a separate bottle. Have ready a clean glass vessel of a size sufficient to contain the glass plate to be silvered; when everything is ready, mix together the silver solution with that of the sugar of milk, in the proportion of 10 of the former to 1 of the latter. Lower the glass down in the solution until it is a little distance from the bottom, and allow it to remain there for a period varying from 15 minutes to 4 hours, according to the thickness of the coating of silver desired. After removing it from the bath, wash with distilled water, and, when dry, polish by means of a soft pad of cotton-velvet charged with rouge. An intensely brilliant surface may be thus obtained on both sides of the glass plate. Make a 3 gr. solution of ammonio-nitrate of silver. Render it slightly turbid by excess of silver nitrate, and then filter it. Just

before using it, add to each ounce of the foregoing solution 2½ gr. Rochelle salt, immerse the glass as before, and expose to a subdued light while it remains in the bath. In about 2 hours the deposit of silver will be sufficiently thick.

(n) Specula.—Prepare three standard solutions. Solution A—Crystals of silver nitrate, 90 gr.; distilled water, 4 oz.; dissolve. Solution B—Potassa, pure by alcohol, 1 oz.; distilled water, 25 oz.; dissolve. Solution C—Milk-sugar, in powder, ½ oz.; distilled water, 5 oz. Solutions A and B will keep in stoppered bottles for any length of time; solution C must be fresh.

To prepare sufficient for silvering an 8-in. speculum, pour 2 oz. solution A into a glass vessel capable of holding 35 oz. Add, drop by drop, stirring all the time with a glass rod, as much liquid ammonia as is just necessary to obtain a clear solution of the grey precipitate first thrown down. Add 4 oz. solution B. The brown-black precipitate formed must be just redissolved by the addition of more ammonia, as before. Add distilled water, until the bulk reaches 15 oz., and add, drop by drop, some of solution A, until a grey precipitate, which does not redissolve after stirring for 3 minutes, is obtained; then add 15 oz. more distilled water. Set this solution aside to settle. Do not filter. When all is ready for immersing the mirror, add to the silvering solution 2 oz. solution C, and stir gently and thoroughly. Solution C may be filtered.

Procure a circular block of wood, 2 in. thick, and 2 in. less in diameter than the speculum. Into this should be screwed three eye-pins, at equal distances. To these pins fasten stout whipcord, making a secure loop at the top. Melt some pitch in any convenient vessel, and, having placed the wooden block, face upwards, on a level table, pour on it the fluid pitch, and on the pitch place the back of the speculum, having previously moistened it with a little spirits of turpentine, to secure adhesion. Let the whole rest until the pitch is cold.

Place the speculum, cemented to the circular block, face upwards, on a level table; pour on it a small quantity of strong nitric acid, and rub it gently all over the surface with a brush made by plugging a glass tube with pure cotton-wool. Having perfectly cleaned the surface and sides, wash well with common water, and finally with distilled water. Place the speculum, face downwards, in a dish containing a little rectified spirits of wine, until the silvering fluid is ready.

(o) Partially Resilvering Pier Glass. (1) Remove the silvering from the injured part, clean the glass, form a wall of beeswax round the spot, pour on it some silver nitrate, and precipitate the silver by sugar, or oil of cloves and spirits of wine. This does not leave a white mark round the prepared place.

(2) If the silvering is frosted or damp-marked in places, carefully remove the silvering from these parts, squaring it off sharply with straight-edge and keen knife. Lay the glass flat down and pour on a silvering mixture as given in (a) or (b), letting it flow evenly over the bare place.

(p) Curved Glass.—This is a French process, used not only for flat surfaces, but also for those which are curved, or cut into patterns. Dissolve 600 gr. neutral silver nitrate in 1200 gr. distilled water, add 75 drops of a solution composed of 25 parts distilled water, 10 ammonia sesquicarbonate, and 10 ammonia, sp. gr. 0·980; add also 30 gr. ammonia, same sp. gr., and 1800 gr. alcohol, sp. gr. 0·85. When clear, the liquor is decanted or filtered, and mixture of equal parts alcohol and oil of cassia is added to the silver solution in the proportion of 1 of the oil of cassia to 15 of the silver solution; the mixture is agitated and left to settle, then filtered. Before pouring upon the glass surface, or into the glass vessel to be silvered, the solution is mixed with 1-75th its bulk of essence of cloves, 1 part oil of cloves,

3 parts alcohol. The glass is thoroughly cleaned, and the silver solution is applied and warmed to 100° F. for about 3 hours; the liquid is poured off, and the silver deposit is washed, dried, and varnished.

(*q*) Watch Glass.—Take a solution of silver nitrate in a watch glass (1 gr. of the salt to 30 c.c. water), add very dilute ammonia, drop by drop, until the precipitate formed is partially dissolved. Add a drop of a solution of sodium and hydrogen tartrate. The liquid will turn black and the silver will be deposited on the watch glass, forming a brilliant mirror-like coating. The watch glass should be embedded in some sand, and the sand gently warmed.

(*r*) Glass Globes.—(1) Take ½ oz. clean lead, and melt it with an equal weight of pure tin; then immediately add ½ oz. bismuth, and carefully skim off the dross; remove the alloy from the fire, and before it grows cold add 5 oz. mercury, and stir the whole well together; then put the fluid amalgam into a clean glass, and it is fit for use. When this amalgam is used for silvering, let it be first strained through a linen rag; then gently pour some ounces thereof into the globe intended to be silvered; the alloy should be poured into the globe by means of a paper or glass funnel reaching almost to the bottom of the globe, to prevent it splashing the sides; the globe should be turned every way very slowly, to fasten the silvering.

(2) Make an alloy of 3 oz. lead, 2 oz. tin, and 5 oz. bismuth; put a portion of this alloy into the globe, and expose it to a gentle heat until the compound is melted; it melts at 197° F.; then by turning the globe slowly round an equal coating may be laid on, which, when cold, hardens and firmly adheres. This is one of the cheapest and most durable methods of silvering glass globes internally.

(3) Silver nitrate, 1 oz.; distilled water, 1 pint; strong liquor ammoniæ, sufficient quantity, added very gradually, to first precipitate and then redissolve the silver; then add honey, ½ oz. Put sufficient quantity of this solution in the globe, and then place the globe in a saucepan of water; boil it for 10–30 minutes, occasionally removing it to see the effect.

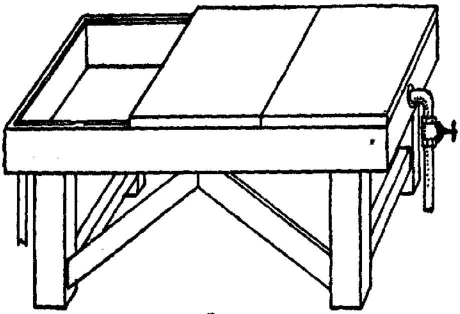

FIG. 42.

(*s*) *A Table for Plate-Glass Silvering.*—The silvering of large mirrors or plate-glass is done on a moderately hot table, the hotter the table the quicker the silver will be deposited. Fig. 42 shows such a table. The body of the table may be described as a shallow zinc-lined trough or tank

covered on top with slabs of slate. 1 in. board is used for the body of the table, 1½ in. slate for the top. The illustration shows a piece of slate removed. The slate is bedded on with red-lead and varnish to make it steam-tight. The slate top, when about to be used, has a blanket or felt cover, wetted with water before the heat is turned on. At one end of the body is the steam-pipe and valve, and the steam is turned on very gradually when first heating up. At the other end of the body is an outlet, and the steam-valve must be regulated so that while sufficient steam enters for the purpose very little is wasted by escaping from the outlet. This outlet also discharges condense water and prevents steam pressure lifting the slates. The silvering process is to have the glass chemically clean and while still wet from the washing place it on the hot table, and at once pour over it a solution of gelatine or other mordant. Before this is dry cover the surface with the nitrate of silver solution and let it remain ten minutes. Then wipe over with a leather squeegee and apply the silver solution again. Complete by wiping again with the squeegee.

MODELLING

IN CLAY AND WAX, AND CASTING IN PLASTER.

(*See also* PLASTER AND PLASTER-WORK, ETC.)

MODELLING in some plastic material is the first step in learning to execute work in more solid materials, such as wood and stone. With a plastic substance, such as clay, it is possible to correct errors and introduce improvements while the design is in course of development, and various ideas can be worked out easily and rapidly in a preliminary manner which will indicate very faithfully what the effect would be in wood or marble, papier maché or leather. Moreover, when proper clay is used, the model itself may be baked and rendered permanent.

The Workshop.—The room or workshop where modelling is to be carried on should be reserved for that purpose, or a portion of a room may be so used. The floor should either be bare boards or covered with oil-cloth. Under a window should stand a firm table, with the light falling on it either in front or on the left side. This table will be surmounted by a slate or stone

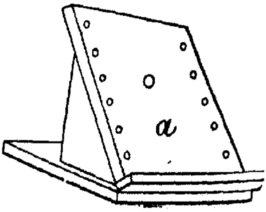

FIG. 43.

slab, or by a wooden stand on which the clay is manipulated. A slab is preferable to wood, as being unaffected by the moisture exuding from the clay.

When a wooden stand is used, it may take the form shown in Fig. 43. This is made of ordinary deal, the sides being well clamped to insure rigidity, and a couple of coats of paint or varnish being applied all over as a preservative. The working face *a* will be much improved by laying a piece of school-slate over it. The dimensions of *a* must in some measure depend on the work in hand, but about 2 ft. from side to side, and 1½ ft. from top to bottom edge are average figures. The height above the floor should be such that the work to be modelled comes level with the workman's face, standing. A handy accessory to the modelling stand is a miniature turn-table carrying the slate; a piece of board with a pin attached to the back fitting into the hole in *a* will answer the purpose, and greatly facilitates getting at all sides of the object under the treatment: but it has this disadvantage, that a certain degree of instability is introduced; slate on the modelling stand may be replaced by covering the latter with sheet lead or zinc, anything in fact which will not absorb moisture.

Material.—(*a*) Pottery clay.—Many workmen employ ordinary blue clay such as is used for making earthenware, and commonly known as kaolin. This may be purchased at the places where it is dug, in Dorset, Devon, Cornwall, etc., or from potters in any part of the kingdom. In large quantities it costs about 3*l*. a ton; in lesser parcels about 4–5*s*. a cwt., and in still smaller about a 1*d*. a lb. But not less than a ¼ cwt. is of any service, as its weight is disproportionately greater than its bulk. In quality it should be as pure as possible, not gritty, and capable of being freely worked. Colour is no guide, being due to the presence or absence of a small proportion of iron, and varying accordingly from a reddish-brown to a pale-grey tint. When purchased from dealers at about 10*s*. a cwt. it should be in a fit state for use; but when bought at the pit or from the potter it will be in the rough state, and must undergo a refining process before application.

This refining process consists in very carefully cutting the mass up by means of wires fitted in handles, which will reveal the presence of any coarse or gritty particles. Or it may be subjected to a thorough beating with an iron bar, all foreign matters being picked out as discovered. This must be followed by a kneading process, whereby its consistence is rendered suitable and homogeneous. Suitability in this case means somewhat softer than putty, so that it can be freely and readily worked and formed by the fingers. If it becomes too soft, this can be remedied by leaving it open to the air for a while, when it soon loses part of its moisture; if too dry, it must be broken up in water and re-kneaded, unless adding a little water and folding a wet cloth round it will suffice, as it sometimes does. The addition of a little fine sand well incorporated with the mass facilitates the working, especially in large objects.

Having worked the clay into good condition, the next thing is to keep it so, which simply means preventing it from drying. Nothing answers the purpose better than a glazed earthenware pan of a capacity of 6–7 gal., which can be furnished with a wooden cover, and at the bottom of which a little water is put. Here the clay will remain soft for many weeks. Even when not in use, clay should never be allowed to get quite dry, but always put in the pan with water and worked up. The more it is used the better it becomes, getting seasoned as it were. As soon as a model is done with, it should be broken down into walnut-sized pieces, very carefully examined for possible impurities, and put to soak at once. The same rules as to moisture hold good in the unfinished or finished model as in the original clay. Without application of moisture the clay will quickly dry, the sequel to which is shrinkage and cracks. The remedy is to occasionally sprinkle the model with water from a brush or

spray-bottle while at work on it, and to always keep it surrounded by a moist envelope when not at work on it. This envelope usually takes the form of calico next the model, and coarser more absorbent cloths outside; and when it is desirable not to allow contact between the envelope and the model, the latter is protected by a slight wooden framework, or by inserting little sticks into the model where they can do no harm, and holding the cloths off by their projecting ends. As an extra precaution, a waterproof material may form an outside covering, as it will more effectually prevent evaporation. Changes of temperature should be guarded against, and especially extremes, whether of heat or cold.

(*b*) Pipeclay.—Much the same conditions apply to pipe-clay as to china clay. It may be obtained of plasterers and pipemakers, the latter being less likely to contain fragments of plaster of Paris, for which it must be carefully examined.

The Tools.—The tools required are of the simplest description, and may all be made at home, or purchased from edge-tool dealers. Those made from any hard close-grained wood such as pear, are just as good as more expensive articles in bone or ivory. Fig. 44 is a chisel-shaped tool with a bent point; Fig. 45, a flat blade with one edge smooth and the other serrated; Fig. 46, a double spoon-shaped or bent spatula; Fig. 47, a combined sword-blade and pointed spoon; Fig. 48, an oblique chisel edge and sharply curved spoon bowl; Fig. 49, flat bowls for roughing out; Fig. 50, a combined bent point and toothed blade; Fig. 51, a wire tool; Fig. 52, a toothed rake of brass wire, which may be in several sizes, from ½ in. to 3 in. across the edge *a*; Fig. 53 a handled blade of flattened brass wire. All the wooden tools can be easily cut out of pearwood with a pocket knife, and finished with a rasp and fine sand-paper. They are mainly destined to replace the modeller's thumb where that cannot be used, and the chief thing to guard against is the occurrence of points or sharp edges. A few old pieces of pearwood at hand will always enable the modeller to cut a new tool for any particular piece of work in hand. The simplest is the best. Other necessaries will be a serrated straight-edge about 18 in. long for smoothing backgrounds, a fine sponge, a plummet, a pair of callipers which will embrace the shoulders, and a pair of compasses.

Method of Operation.—Select a very simple image on which to try your prentice hand. Place it at a convenient height level with the modelling table. Prepare a foundation of the necessary thickness, taking great care to work it into a uniform and coherent mass. Level it true with the straight-edge, and place temporary strips of wood at the sides, as a guide. From the mass carve away very gradually, by a scraping motion, from the necessary parts so as to create a broad general resemblance to the selected object, always avoiding taking away too much, and frequently checking dimensions by the compasses and callipers. It will only be after some practice that the eye will be able to grasp the essential features, and detailed work should not be attempted till success attends the efforts made in bolder subjects. The most important point is to so work that the whole operation shall consist in cutting away, and avoid having to build up. Added portions will rarely have exactly the same consistence as the body, and unless very carefully attached will be insecure. Solid objects, such as animal images, busts, etc., will be the easiest to commence on. Foliage and articles of fine texture are much more difficult to imitate.

The first step in laying the foundation is to accurately sketch the outline of the proposed object on the modelling board, by means of pencil or crayon. Commence with clay that is fully soft, and always avoid retaining it too long in the hand, as it thereby soon dries and loses its cohesion.

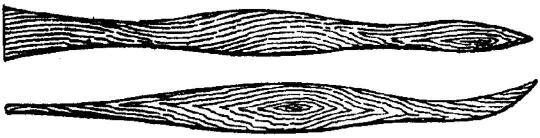

FIG. 44

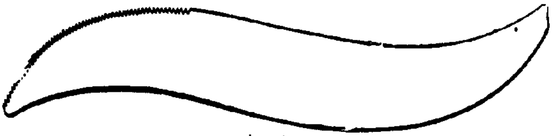

FIG. 45.

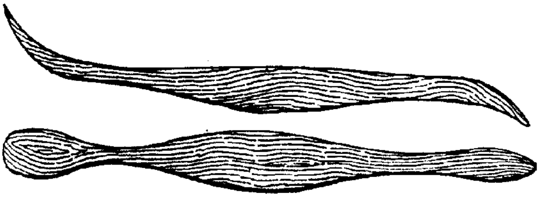

FIG 46.

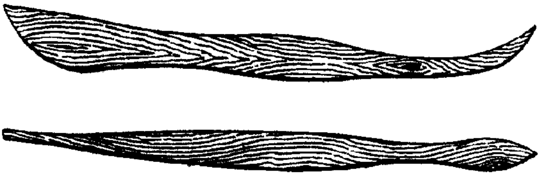

FIG. 47.

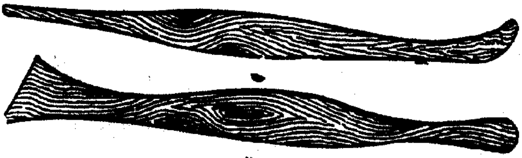

FIG. 48.

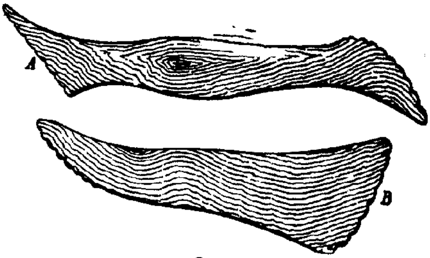

FIG. 49.

FIG. 50.

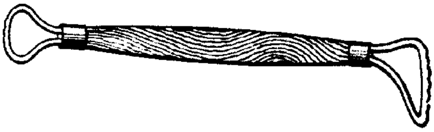

FIG. 51.

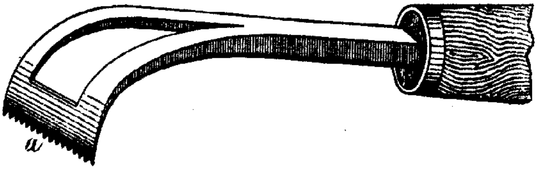

FIG. 52.

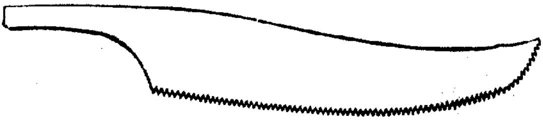

FIG. 53.

Work the clay into little rolls and lay it on by holding the roll in one hand and pressing the clay into place with the other. The chisel-shaped tool is employed to keep the clay correctly to the pattern, and the greatest care must be exercised to press it perfectly down and prevent any air bubbles or other impediments to absolute adhesion between clay and board. The foundation must be finished all over before any building up is attempted. This refers, of course, to flat work, such as panels, which are afterwards to be copied in wood. When making additions, it is very essential that both surfaces to be joined should be somewhat softer than the bulk.

Wax Modelling is better adapted for small objects. The material consists of wax slightly coloured by the addition of a pigment and somewhat softened by a solvent. A good recipe is said to be: 200 parts clear wax, 26 Venice turpentine, 13 lard, and 145 precipitated bole, mixed and well kneaded in water. But many prefer to purchase prepared wax from an artists' colourman. The tools used are the same as for clay, but smaller, blunter, and generally of bone. The operation consists in building up rather than cutting down; and the chief precaution is to keep the tool moistened with water to prevent adhesion. Considerable practice with clay is a good preliminary to trying wax.

Plaster Casting.—(1) The model (of clay or otherwise) is first covered with a layer of good plaster-of-Paris mixed, or "gauged," as plasterers call it, to the consistence of batter, and coloured with a little red or yellow ochre. This layer should average about ⅛ in. thick. It is best applied with the pewter or metal spoon used to mix the plaster with. The plaster is mixed in a basin half full of water, into which it is sprinkled by the hand, as oatmeal is sprinkled in making stirabout; when the plaster reaches the surface of the water, it is about sufficient, but experience soon teaches the right proportion. The mixed plaster can be jerked by a dexterous twist of the spoon into the deep undercut places, and care must be taken not to inclose bubbles of air. A practical moulder would place the clay slab in a vertical position, as he would see the process of his work better. A large model would require several mixings of plaster, as when the plaster begins to set or harden, it is useless for moulding. When the first coloured coat of plaster is hardened, a wash of clay-water should be applied nearly all over it, and the second coating, which may be of coarser stuff, put on to the thickness of about 1 in. If the mould is very large, some strips of iron nail rod, ¼ in. square, may be imbedded in the back of the mould to prevent warping. When the mould is set hard, it must be turned over and the clay picked out. If the work has been modelled on a board or slate, or best of all, on a plaster slab, it may be necessary to pass a wire between the clay and the board to separate them. When the mould has been well cleaned and washed with a soft brush, it should be soaked in a tub of water until quite saturated through and through, drained, but not wiped, and a sufficient quantity of superfine plaster, carefully mixed, poured into it, and, by moving the mould about, carefully distributed all over. This may be backed with coarser plaster, and strengthened with iron rods, which in this case should be painted or coated with a varnish of rosin and tallow. When the cast is set hard, the most difficult part, called "knocking out," begins. A light mallet and a carpenters' firmer chisel, by a few dexterous strokes applied upon the edge, will separate the coarse outer backing of the mould, prevented from the wash of clay water from adhering to the first coloured layer. The cast should then be placed upon a soft elastic bed—an empty sack folded is as good as any—and by gentle taps, holding the chisel perpendicularly or nearly so, to the face of the work, the coloured plaster may be snapped off, sometimes in large, sometimes in minute pieces,

the colour preventing the operator chipping away the best part of his work, which may happen when mould and cast are of one colour. A chisel 1 in. or more broad may be used for the first rough work; smaller will be required for more delicate work.

A figure in the round may be moulded by the same process, but the mould must be in two parts. A strip of clay 1 in. or so wide must be fixed all round the clay figure, to be removed when the first half of the mould is done. The edge of the first half must have sunk holes, made by any convenient steel modelling tool to insure the fitting of the two halves of the mould. Projecting limbs must be cut off with a fine wire and cast separately. If an iron support enters the back of the model, a little clay must be put round it, close to the model to enable the iron to be drawn through the mould and the hole in the mould stopped up with plaster. The two parts carefully saturated and bound together, may be about half-filled with well-mixed superfine plaster, as thick as cream, which, by carefully turning and inclining the mould, can be made to cover the whole of the mould, leaving a large hollow to be filled with a coarser plaster, in which a painted iron rod may be inserted. Good plaster smells sweet, sets in 10-20 minutes as hard and as crisp as loaf sugar. Bad plaster smells of sulphur, and never sets hard. Beginners must make sure of their materials, and even then try their hands on unimportant work.

Small reliefs may be moulded in wax. A border of clay or strips of wood a little higher than the highest part of the model must be fixed all round, and melted beeswax with a little rosin and tallow added poured over the clay. When the wax is cold, and the clay well washed out, superfine plaster can be poured in as into a plaster mould. The wax is afterwards melted off or softened before a fire and peeled off, to serve again as often as you please. Hands and arms, and legs and feet, can be easily moulded in plaster, care being taken to grease or oil the skin well. The outside of the moulds may be deeply scored before the plaster sets, so as to break off in convenient pieces for putting together again.

Plaster Casts from Life.—(*a*) In taking the cast of the face of a living subject (or victim), he or she should be placed sitting in a chair as if about to be shaved; the skin carefully greased, the hair and eyebrows smoothed down with clay or soft soap and superfine plaster, slightly coloured with ochre, mixed in warm water, dexterously splashed over the face with a silver spoon, care being taken to leave the nostrils free. The mould should not be quite ½ in. thick, and may be broken off in two or three pieces, which can be afterwards joined.

(*b*) One of the chief difficulties in making a plaster cast from life lies in the fact that it must be done quickly. The first thing to be done is to well oil the skin to prevent the plaster adhering to it. Whatever hair has to be covered can be smoothed down with butter or margarine, rather thickly applied.

In dealing with the face it is necessary, of course, that the mouth and eyes be closed, while the nostrils are stopped with wax through which two quills are inserted to admit of breathing. If an arm is to be modelled, then, as the weight of plaster may be considerable, it had best be supported at both wrist and elbow. This will prevent involuntary or muscular movements, the latter being brought about by the added load of plaster. Any such movement produces bad results by causing the plaster to slip, and similar reasons may be offered for getting the work done quickly.

As a rule the plaster sets quickly enough for all ordinary purposes, but the setting can be made faster by the addition of powdered alum to the plaster. Ordinary salt will also do, but it has the fault of making the plaster more adhesive. This can, however be overcome by using more oil or grease,

but this remedy has a tendency to spoil the natural surface effect that can otherwise be obtained.

A little thought should be given, before commencing work, as to the number and shape of pieces the plaster shell should be divided into when removing it from the human model. The reason for this is that the plaster should be taken off as quickly as possible when it is set, without the delay of considering how best it should be divided up. The common practice is to use a wax thread for cutting, but as the plaster shell cannot be made very thick, breakages frequently occur, and much skill is necessary in putting together the pieces of the mould in order to get a cast from them.

The interior surface of the mould is coated with shellac to render it less absorptive, and must be freshly oiled before using. It is useful in addition to mix a little colour in the plaster that is prepared for the cast, so that if even a trace of it adheres to the inside of the mould it will be detected, in which case it is to be carefully removed with a sharp pen-knife blade, and adjusted in its proper place on the cast; for, as before said, the special beauty of a cast from life is in its natural surface. A little powdered yellow or red ochre will give a nice tint to the plaster. It is important that the plaster be well mixed, and much depends on quickness. Plenty of plaster should be in readiness, and it should be mixed as thick as the water will hold, leaving about an inch of water at the top of the pail.

(2) *To Prepare plaster-of-Paris.*—Immerse the unburnt gypsum for 15 minutes in water containing 8-10 per cent. of sulphuric acid, and then calcine it. Prepared in this way it sets slowly, but makes excellent casts, which are perfectly white instead of the usual greyish tint.

(3) *Transparent Casts.*—Beautiful semi-transparent casts of fancy articles may be taken in a compound of 2 parts unbaked gypsum, 1 of bleached beeswax, and 1 of paraffin. This becomes plastic at 120° F., and is quite tough.

(4) *To Toughen Casts.*—Immerse in a hot solution of glue long enough for the mass to be well saturated. They will bear a nail driven in without cracking.

(5) *Mending Models.*—Sandarach varnish is the best material. Saturate the broken surfaces thoroughly, press them well together, and allow them to dry.

(6) *Plaster Moulds.*—Glycerine is said to be a good coating for the interior, but practical plaster moulders still use, as of old, a mixture of lard and oil.

(7) *With Small Models.*—For making small models in plaster, gelatine is generally used. Good glue, mixed with treacle or glycerine, answers every purpose. The composition that the "chromograph" is made of will answer very well. The model is immersed in it, and, when cool, a cut is made with a sharp knife, and the elastic nature of the composition allows the model to be taken out. The mould should be greased before the plaster is poured in; when set, it is extracted in the same manner as the original model. Large figures are poured in plaster moulds; these are made in pieces, which are fitted together with wooden pegs. The peg is inserted in one piece before the plaster sets. This piece is trimmed off, in order to prevent the wet plaster adhering to the next piece; the latter should be greased with lard; the whole of the mould is thus built up of pieces. In pouring the model, pieces of wood or wire should be placed in the legs or arms to strengthen them. To cast brass in plaster, the mould should be previously made hot, which might be fatal to the stability of the plaster.

(8) To make casts or moulds of plaster-of-Paris from metal types, without air-bubbles or "picks," use the finest and purest plaster-of-Paris obtainable. When filling a mould, learn to beat up the requisite quantity of cream quickly, and with care to

avoid making it too thick. In pouring this in, use a good camels' hair brush to displace air-bubbles; a mere surface cover of this thin cream is all that is requisite. While doing this, have ready the thicker plaster, of the consistence of light syrup, and fill up the mould at once. In about 20 minutes you can open the mould, if your plaster is pure and has been properly mixed. If you do not put too much oil on the type, and have used your brush properly, you will find clear, sharp moulds.

(9) Metal may be cast in moulds made of plaster-of-Paris and talc mixed; or of pounded pumice and plaster-of-Paris in equal quantities, mixed with washed clay in the same proportion. The mould must be heated very hot when used, if the cast is to be made of copper or brass, but a less degree of heat will serve for lead and tin. You may safely use plaster for zinc castings, taking the precaution of thoroughly drying the parts of the mould, e.g. in the kitchen-range oven; care, however, must be taken not to use too much heat, or the plaster will be burned—just as much as is unpleasantly hot to the hand. The zinc should not be hotter than will give it sufficient fluidity for pouring. In this way 4 or 5 good castings may be taken, after which the mould gets cracked and scales on the surface; this spoils it for fine work, but is of little consequence for battery zincs.

(10) *Carved Objects.* — In many cases it is advisable to preserve copies of small carved objects for future use, and this is easily done by taking a plaster cast of the work. To take an impression of the object of which a cast is desired, a substance known as squeeze-wax is used, and this is made of the following ingredients, viz.: 2 lb. flour, ½ lb. best beeswax, ¼ lb. linseed-oil, and a small quantity of rouge; these should be thoroughly mixed together, and then exposed to the air. Should the squeeze-wax become hard at any time, it may easily be softened by slightly warming and well kneading. In taking a cast, the wax should be well pressed into every portion of the work and then gently withdrawn, the mould thus formed being filled with plaster-of-Paris, the plaster having been mixed with water until it is of the consistence of cream. After standing for a few hours the squeeze-wax can be taken off, leaving a copy of the carving in plaster. Care should be taken to obtain the plaster fresh, as after being exposed to the air it loses some of its properties, and does not harden well. These remarks on taking plaster-casts apply only to small objects that are not deeply undercut; larger casts, and casts of subjects carved on more than one side, are taken in sections.

(11) *Anatomical Specimens.*—Prepare the specimen by making it as clean as possible; place on oiled paper, in a position that will show it to advantage. Soft projections may be held in position with threads suspended from a frame or from a heavy cord stretched across the room. Paraffin melted on a water bath is painted over the preparation with a soft brush, the first layer being put on with single and quick strokes, that the rapid cooling of the paraffin may not cause the brush to adhere to the preparation, thus drawing the soft tissues out of place, until the mould is formed about ⅛ in. thick; all undercuts must be well filled. When the mould is hard it can be readily separated from the preparation; it is then well washed with cold water. Stir fine dental plaster into cold water to consistence of cream, pour into the mould and out again several times, so that there will be no air bubbles on the surface, then fill the mould and let it stand until hard. Place the whole in a vessel containing boiling water until the paraffin is all melted; wash with clean boiling water. When the cast is thoroughly dry, it may be painted with oil colours by coating it first with shellac varnish. Casts of any part of the body may be made from a living subject, if the parts are not

too sensitive to bear the heat of the paraffin, which varies from 104° F. to 140° F.

(12) *Natural Objects.* — Taking plaster casts of natural objects is thus explained by Prof. Boyd Dawkins: The material of the mould is artists' modelling wax, which is a composition akin to that used by dentists; and as it becomes soft and plastic by the application of heat, though in a cold state it is perfectly rigid, it may be applied to the most delicate object without injury. As it takes the most minute markings and striations of the original to which it is applied, the microscopic structure of the surface of the original is faithfully reproduced in the cast. The method is briefly this: Cover the object to be cast with a thin powder of steatite or French chalk, which prevents the adhesion of the wax. After the wax has become soft, either from immersion in warm water or from exposure to the direct heat of the fire, apply it to the original, being careful to press it into the little cavities. Then carefully cut off the edges of the wax all round, if the undercutting of the object necessitates the mould being in two or more pieces, and let the wax cool with the object in it, until it is sufficiently hard to bear repetition of the operation on the uncovered portion of the object. The steatite prevents the one piece of the mould sticking to the other. The original ought to be taken out of the mould before the latter becomes perfectly cold and rigid, or it will be very difficult to extract. Next pour in plaster-of-Paris, after having wetted the mould to prevent bubbles of air lurking in the small interstices; and if the mould be in two pieces, it is generally convenient to fill them with plaster separately before putting them together. Dry the plaster casts either wholly or partially. Paint the casts in water-colours, which must be fainter than the hues of the original, because the next process adds to their intensity. The delicate shades of colour in the original will be marked in the cast by the different quantity of the same colour which is taken up by the different textures of the cast. After drying the cast, steep it in hard paraffin: ordinary paraffin candles will serve the purpose. Cool, and hand-polish the cast with steatite.

(13) *Photographic Plaster Casts.* — The following method of taking plaster casts by means of photography originated with Fink.

An ordinary piece of patent plate-glass, which should measure 2 or 3 in. each way bigger that the original, is coated in the dark-room with a mixture made up of the following solution: In 15 oz. water is dissolved 1 oz. potash bichromate, the former being warmed gently, and then gradually 2 oz. gelatine are added. As soon as the latter has dissolved, and the solution has about reached the simmering point, it should be filtered though fine linen into a glass beaker, and then poured upon the glass plate above referred to. The gelatine solution is poured upon the centre of the plate, and then drawn towards the margins by means of a fine brush. It is applied again and again until the thickness amounts to about 1½ line. As plates prepared in this way require 2 to 3 days to dry, it is well to prepare a good many at one time, and to place them when dry in a box well screened from the light. The sensitiveness of the plates has not been found to suffer, even after preservation for a period of 6 weeks.

When a suitable negative has been obtained of the object, and, furthermore, a diapositive from the negative, the prepared plate is placed, face downwards, against the collodion side of the cliché in the printing-frame, and printed in diffused daylight for a period varying from 10 to 40 minutes. The plate is then taken out of the printing-frame (in the dark room), put into a dish, and poured over with lukewarm water until the relief is fully developed. The plate is then dried by means of filter-paper, and coated with glycerine (any superfluity of this substance being also removed with filter-paper), a fine

and large badger brush being employed for the purpose.

The plate, which has hitherto been manipulated in the dark, may, after the development of the relief, be further manipulated in daylight, and the plaster cast proceeded with in an ordinary workroom. The manner of making the cast is as follows: In a couple of evaporating dishes, some alabaster gypsum is put, and two mixtures are made with ordinary spring water, one having the consistence of oil, and the other that of thick cream. The gelatine mould is taken in one hand and a little of the thinner plaster liquid is poured upon it, the mould being at the same time tapped with the open hand from the bottom, in order that no air-bubbles be formed. After this the plate is placed horizontally upon a table, and the thicker paste is poured on, making a film ⅛ to ¼ in. high. This latter, after it has stood for 15-18 hours, is carefully separated at the edge with a knife, and by employing a little force the cast is removed from the mould. This plaster cast may be employed for many purposes, and will serve for taking a casting from, with a metal fusible at a low temperature. With amateurs and photographers, such a proceeding is, however, difficult, and if a metallic cast is required it is best to send the plaster one to a type-foundry or similar establishment. Retouching may be done if necessary with a needle upon the plaster cast. There is not so much difficulty in taking metallic casts from the plaster moulds. It is only necessary to thoroughly bake the casts, and while still warm brush over with a little wax. ('Eng. Mech.')

(14) *Casts that can be Washed.*—A prize offered by the Prussian Minister of Commerce and Industry for a method of preparing plaster casts that permit of being washed was conferred upon Dr. W. Reissig, of Darmstadt. From Dr. Reissig's essay on the subject the following points are abstracted:—

In preparing these casts it is not only desirable to obtain a surface which should not wash away, but also to include a simple process for preventing dust entering the pores, and render them more easily cleansed. Laborious experiments showed that the only practical method of accomplishing this and retaining the sharpness of outline was to convert the lime sulphate into (1) baryta sulphate and caustic or carbonate of lime, or (2) into lime silicate by means of potash silicate. Objects treated in this way are not affected by hot water or hot soap solutions, but from the method of preparation, they remain porous, catch dust, etc., and when first put into water eagerly absorb all the impurities. To avoid this evil, subsequently coat the articles, now rendered waterproof, with an alcoholic soap solution, which penetrates more easily, deeper, and more freely into the pores than an aqueous solution. After the alcohol evaporates, a layer of soap remains, which fills the pores, and when washed it is converted into a sud which removes the dust without allowing it to penetrate.

(*a*) Process with Baryta Water.—This is the simplest, easiest, and cheapest method. It depends upon the fact that gypsum, or lime sulphate, is converted by baryta water into baryta sulphate (which is totally insoluble), and caustic lime, which latter is converted by contact with the air into lime carbonate. The practical method of carrying this out is as follows: A large zinc vessel is required with a tight-fitting cover. In each vessel is a grating made of strips of zinc, resting on feet 1½ in. high. This vessel is ¾ filled with soft water at 54° to 77° F. (12° to 25° C.), and to every 25 gal. of water is added 8 lb. fused or 14 lb. crystallised pure hydrated barium oxide, also 0·6 lb. lime previously slaked in water. The solution stands about 4° Beck (1·0241 sp. gr.). As soon as the baryta water gets clear, it is ready to receive the casts. They are wrapped in suitable places with cords, and after removing the scum from the baryta bath, are dipped in as rapidly

as possible, face first, and then allowed to rest upon the grating.

Hollow casts are first saturated by rapid motions, then filled with the solution and suspended in the bath with the open part upwards. After the cords are all secured above the surface of the liquid, the zinc vessel is covered. The casts are left in it for 1 to 10 or more days, according to the thickness of the waterproof strata required. After taking off the cover and removing the scum, the plaster casts are drawn up by the strings, rinsed off with lime-water, allowed to drain, carefully wiped with white cotton or linen rags, and left to dry, without being touched by the hands, in a warm place free from dust. The same solution which has been used once can be employed again by adding a little more baryta and lime.

Of course this process can only be applied to casts free from dust, smoke, dirt, coloured particles of water, rosin, varnish, soap, animal glue from the moulds, or sweat from the hands. To prevent the casts getting dust upon them, they should be wrapped in paper when taken from the mould, and dried by artificial heat below 212° F. (100° C.). If, in spite of every precaution, the casts when finished show single yellow spots, the latter can be removed in this manner: The perfectly dry, barytated casts, saturated with carbonic acid, are painted over with water and oil of turpentine, then put in a glass case and exposed to the direct rays of the sun.

(b) Process with Silicate of Potash Solution.—This depends upon the conversion of the lime sulphate into lime silicate, an extremely hard, durable, insoluble compound, and is accomplished by the use of a dilute solution of potash silicate containing free potash. To prepare this solution, first make a 10 per cent. solution of caustic potash in water, heat to boiling in a suitable vessel, and then add pure silicic acid (free from iron) as long as it continues to dissolve. On standing, the cold solution usually throws down some highly-silicated potash and alumina. It is left in well-stoppered glass vessels to settle. Just before using, it is well to throw in a few bits of pure potash, or to add 1 or 2 per cent. of the potash solution. If the plaster articles are very bulky, this solution can be diluted to $\frac{1}{2}$ with pure water.

The casts are silicated by dipping them (cold) for a few minutes into the solution, or applying the solution by means of a well-cleaned sponge, or throwing it upon them as a fine spray. When the chemical reaction, which takes place almost instantly, is finished, the excess of the solution is best removed with some warm soap-water or a warm solution of stearine soap, and this finally removed with still warmer pure water.

The casts, which can be immersed or easily moved around, may be treated as above when warm; a very short time is required, but some experience is necessary. In every case it is easy to tell when the change is effected, from the smooth dense appearance, and by their feeling when scratched with the finger-nail. It is not advisable to leave them too long in the potash solution, as it may injure them. A little practice renders it easy to hit the right point. The fresher and purer the gypsum and the more porous the cast, the more necessary it is to work fast. Castings made with old and poor plaster-of-Paris are useless for silicating. These silicated casts are treated with soap as above.

In washing plaster casts prepared by either method, use a clean soft sponge carefully freed from all adherent sand and limestone, wet with lukewarm water, and well soaped. They are afterwards washed with clean water. They cannot, of course, be washed until thoroughly dry and saturated with carbonic acid. The addition of some oil of turpentine to the soap is useful, as it bleaches the casts on standing. The use of hot soapsuds must be avoided.

(15) *Hardening Plaster.*—Following is a new process of hardening plaster

so as to adapt it to the construction of flooring in place of wood, and to other purposes for which it cannot be used in its ordinary state on account of its want of hardness and resistance to crushing. Julte recommends the intimate mixture of 6 parts plaster of good quality with 1 part finely sifted recently slaked white lime. The mixture is employed like ordinary plaster. After it has become thoroughly dry, the object manufactured from it is saturated with a solution of any sulphate whose base is precipitated in an insoluble form by lime. The sulphates best adapted for the purpose, form every point of view, are those of iron and zinc.

With zinc sulphate, the object remains white, as might be supposed. With iron sulphate, the object, at first greenish, finally assumes, through desiccation, the characteristic tint of iron sesquioxide. The hardest surfaces are obtained with iron, and the resistance to breakage is 20 times greater than that of ordinary plaster. In order to obtain a maximum of hardness and tenacity, it is necessary to temper the limed plaster well in as brief a space of time as possible, and with no more water than is strictly necessary. The object to be hardened should be very dry, so that the solution employed may penetrate it easily. The solution should be near the point of saturation, and the first immersion should not exceed 2 hours. If immersed too long, the plaster would become friable.

The proportions of lime and plaster may be varied according to the results to be obtained; nevertheless, the proportions of 1 to 6 have given the best results.

As it is important that the plaster should not be spread over the surface by passing and repassing the trowel for too long a time, the fastest workman will always be the best one to employ. When sulphate of iron is used, the slabs are of the colour of iron rust; but if linseed-oil boiled with litharge be passed over the surface, they assume a beautiful mahogany colour, and offer a certain superficial elasticity to the tread. If a coat of hard copal varnish be added, the colour becomes very beautiful.

On spreading a 2 or 3-in. layer of limed plaster in a room, and treating it in the way above described, is produced a floor which is smooth, and which, in most cases, fulfils the office of an oak floor, but which has the advantage over the latter of costing one fourth. ('Scient. Amer.')

(16) *Reducing and Enlarging Plaster Casts.*—Ordinary casts taken in plaster vary somewhat, owing to the shrinkage of the plaster; but it has hitherto not been possible to regulate this so as to produce any desired change, and yet preserve the proportions. Höger has however, recently devised an ingenious method for making copies in any material, either reduced or enlarged, without distortion.

The original is first surrounded with a case or frame of sheet metal or other suitable material, and a negative cast is taken with some elastic material, if there are undercuts; the inventor uses agar-agar. The usual negative or mould having been obtained as usual, he prepares a gelatine mass, resembling the hektograph mass, by soaking the gelatine first, then melting it and adding enough of any inorganic powdered substance to give it some stability. This is poured into the mould, which is previously moistened with glycerine to prevent adhesion. When cold, the gelatine cast is taken from the mould, and is, of course, the same size as the original. If the copy is to be reduced, this gelatine cast is put in strong alcohol and left entirely covered with it. It then begins to shrink and contract with the greatest uniformity. When the desired reduction has taken place the cast is removed from its bath. From this reduced copy a cast is taken as usual. As there is a limit to the shrinkage of the gelatine cast, when a considerable reduction is desired, the operation is repeated by making a plaster mould from the reduced copy, and from this a second gelatine cast is taken

and likewise immersed in alcohol and shrunk. It is claimed that even when repeated there is no sacrifice of the sharpness of the original.

When the copy is to be enlarged instead of reduced, the gelatine cast is put in a cold water bath, instead of alcohol. After it has swollen as much as it will, the plaster mould is made as before. For enlarging, the mould could also be made of some slightly soluble mass, and then by filling it with water the cavity would grow larger, but it would not give so sharp a copy.

MOTOR CAR TROUBLES,

AND HOW TO REMEDY THEM.

THE following notes deal with the lesser troubles which bring a car to a stop rather than cause an actual breakdown, the symptoms accompanying stoppage or bad running being detailed with the possible explanations.

It would not be within the scope of this work to deal with heavier repairs, and for this the enquirer is referred to one of the excellent manuals issued by the proprietors of the 'Model Engineer.'

In a multicylinder engine the trouble may be due to the bad working of one cylinder only, and the first step must be to find out which cylinder it is. This is generally done by cutting off the ignition from all but one cylinder. To do this the armatures or the trembler blades of all but one contact-maker on the coils should be held down, so that only one sparking-plug operates. By running each cylinder separately it can easily be ascertained which cylinder is at fault, and very often from the running of each separately one learns what the trouble is. Some coils are provided with little knobs, which are to be pressed for cutting out cylinders in the manner described. It is better to do this than to press the armatures, as the latter is liable to affect the tension of the armature spring or to bend the trembler blade and so upset the adjustment. With magneto ignition, as a rule, the contact with the plug is made through a switch device enabling the wires to be disconnected from each cylinder. Care must be taken to touch only the insulated parts of these switches, as otherwise a bad shock will be experienced.

Engine Stops Suddenly without any Warning.—(1) Generally due to a wire breaking or to the switch being moved. If the engine is a multi-cylinder one the breakage must be between the battery and

the coil *via* the switch. If the engine is a single-cylinder one, it may be anywhere, even in the high-tension circuit. (2) It may be due to sudden chokage of the jet, or running out of petrol, though this is generally accompanied by one or more misfires and "pops" prior to stopping. (3) It may also be due, but only in a single-cylinder engine, to a broken valve, though the symptoms in this case are generally intermittent. (4) It may be due to the switch having jolted "off."

Engine Misfires and Eventually Stops.—This may be due to: (1) Batteries discharged, recognisable, apart from voltmeter or test lamp tests, by the faint buzz of the coil trembler and the weak spark at the plug. (2) Coil contacts require trimming, symptom same as in (1). (3) Loose terminal or partially broken wire, generally in primary circuit. (4) Oil on contact-maker contacts if of the make-and-break type. (5) Sparking-plug cracked. (6) Short-circuit through or outside the insulation of the sparking-plug. (7) Shortage of petrol, either due to chokage or to lack of petrol in tank, etc. (8) Water in the carburettor. (9) Dirt in the carburettor. (10) Vent in petrol tank choked or covered by the cushion of the car seat. (11) Loss of pressure where petrol is pressure-fed. (12) Overheating due either to: (*a*) Insufficient lubrication; (*b*) Insufficient cooling; (*c*) Insufficient exhaust valve lift; (*d*) Chokage of exhaust outlet. (13) Temporarily wrong mixture.

Loss of Power without Misfires.—This may be due to: (1) Loss of compression. Most frequent. (2) Bad spark due either to weak batteries, badly adjusted coil contacts, or badly adjusted sparking-plug points (distance should be $\frac{1}{32}$ inch). This is rare. (3) Water in the carburettor. (4) Frozen carburettor. (5) Choked jet or carburettor. (6) Flooding carburettor. (7) Stale petrol. This is rare. (8) Vent in petrol tank choked or covered by the cushion of the car seat. (9) Loss of pressure where petrol is pressure-fed. (10) Overheating, due to any of the causes set out above. (11) Insufficient lift of either valve. (12) Spring of either valve too weak. (13) Inlet-valve spring, if automatic, too strong. (14) Temporarily wrong mixture. (15) Timing wrong. (16) Brakes binding, especially in muddy weather. (17) Belt (of motor-cycle) too tight. (18) Ball-bearing (of motor-cycle) adjusted too tight. (19) Silencer outlet choked with mud or soot. (20) Wheels out of track. (21) Bearings require re-brushing.

Engine Fails to Start.—This may be due to: (1) Petrol not turned on. (2) Petrol not reaching the carburettor. (3) Jet choked. (4) The air-inlet on carburettor being open, especially if automatic. (5) The throttle being shut. (6) The carburettor not being flooded. (7) The carburettor being too much flooded. (8) Condensation of the petrol in cold weather. (9) Automatic inlet-valve spring too strong. (10) Automatic inlet-valve stuck to its seating. (11) Broken valve. (12) Switch not on. (13) Batteries discharged or disconnected. (14) Wire disconnected or broken. (15) Terminal loose. (16) Moisture on sparking-plug, either inside or outside. (17) Sparking too far advanced or retarded. (18) Starting handle not turned fast enough, especially with magneto ignition.

Engine Starts badly, but runs well at High Speed.—This may be due to: (1) Partially choked jet, or partially choked fuel supply pipe. Most usual. (2) The air-inlet on carburettor being open, especially if automatic. Most usual. (3) Throttle being shut. (4) Automatic air-intake spring being too weak. (5) The sparking too much advanced. (6) Automatic inlet-valve spring too weak.

Engine Starts Well, Runs Slowly, but not Fast.—This may be due to: (1) Too rich a mixture. (2) Flooded carburettor. (3) Air inlet on carburettor insufficiently opened or

stuck. (4) Chokage in exhaust, either due to insufficient exhaust-valve lift, or choked silencer outlet. (5) Insufficient advance of the spark lever. (6) Partially discharged accumulators. (7) Automatic air inlet-valve spring too strong. (8) Automatic inlet-valve spring too weak.

Engine Runs with the Switch Off.—This may be due to: (1) Short circuit in the primary circuit. (2) Defective switch, which does not break the circuit when in its "off" position. (3) Overheated engine. (4) Some small particle in the cylinder, either loose or on the cylinder wall, which becomes incandescent.

Engine Pre-Ignites.—This may be due to: (1) Overheated engine. (2) Some small particle in the cylinder either loose or on the cylinder wall, which becomes incandescent. (3) An intermittent short circuit in the primary, generally at the contact-breaker. (4) Sparking-plug points which become incandescent.

Popping Noise in Carburettor.—This may be due to: (1) Weak inlet-valve spring. (2) Foreign matter in the inlet-valve seat which prevents the valve closing properly. (3) Weak mixture, due either to choked jet or air-inlet on carburettor too much open. (4) Sudden retarding of the ignition when the engine is running fast. This cannot be avoided.

Explosions in the Silencer. This may be due to: (1) Misfiring. (2) Partially charged accumulator. (3) To one cylinder not working.

Engine Mis-fires.—This may be due to: (1) Partially charged accumulators. (2) Broken or loose wire. (3) Disconnected terminal. (4) Broken bridge in the accumulator. (5) Pitted or wrongly adjusted contacts, either at contact-breaker or coil. (6) Commutator blade not pressing upon the wiping cam. (7) Wiping cam requires cleaning and lubrication. (8) Bad "earthing" from contact-breaker or commutator. (9) Trembler blade on coil bent. (10) Spring on coil trembler become slack. (11) Short circuit anywhere, though generally in the secondary wire. (12) Sparking-plug short-circuiting either outside or inside. (13) Cracked sparking-plug. (14) Central wire of sparking-plug having turned round. (15) Sooted sparking-plug. (16) Too great a gap at the sparking-plug. (17) Vibration shaking switch from its contact. (18) Water in carburettor. (19) Automatic inlet-valve sticking.

Engine Knocks.—This may be due to: (1) Ignition being advanced too much. (2) Pre-ignition from other causes. (*See* above.) (3) Worn bearings. (4) Want of lubrication. (5) Water in the cylinder. (6) Flywheel loose on its key. (7) White-metal bearing run. (8) One or more cylinder, or engine, holding-down bolts loose. (9) Governor balls striking something. (10) Broken spring drive (if any).

Engine Overheats.—This may be due to: (1) Defective pump. (2) Pump not being rotated. (3) Radiators choked. (4) Loss of water. (5) Air-lock in circulation. (6) Want of lubrication. (7) The use of too rich a mixture. (8) Insufficient lift of exhaust-valve. (9) Choked silencer outlet.

Whistling and Blowing Noise at Engine.—This may be due to: (1) Compression-tap open. (2) Crank-chamber drain-tap open. (3) Exhaust joint come adrift. (4) Crack in exhaust system.

Piston Seizes.—This may be due to: (1) Want of lubrication. (2) Piston too tight a fit or of wrong metal. (3) Overheating. (*See* above.) (4) Broken piston ring.

Gears Grind at Changing.—This may be due to: (1) The male cone of clutch spinning, when clutch is out. (2) Clutch not coming out far enough. (3) Spring in the speed lever or its connections. (4) Gear wheel teeth not bevelled off at their edges.

Compression is Bad.—This may be due to: (1) Leaky or pitted exhaust-valve. (2) New exhaust-valve. (3) Combustion-chamber joint leaking. (4) Slots in piston rings in line. (5)

Piston rings sticking in their grooves. (6) Leaky sparking-plug. (7) Too long a valve spindle. (8) Porous cylinder casting. (E. W. Walford.)

MOULDERS' TOOLS

AND THEIR USES.

MOULDERS' tools comprise the rammer, vent wire, trowel, various cleaners, bead and flange, and similar tools used for sleeking, and finally the workmen's hands. Simple though these may appear, their proper employment involves a knowledge of the first principles of the art of moulding. The workmen's hands are purposely included, because in the making of a mould very much often depends on the way in which the hands are used. Tools will often damage a mould, the hands seldom do; the sense of touch is more reliable than the pressure of a tool, and for this reason a good moulder seldom uses the latter when his hands can be of service. Thus, in making an uneven bed for the bedding down of a pattern, the whole surface will be gone over in detail with the hands, in order to judge of its equal consistence, or otherwise; soft places are rendered firm by pressure and the addition of more sand, and the surface is roughened by rubbing the palms of the hands to and fro over it.

Sand is tucked under flanges and ribs and into angles by the hand; pouring basins, too, are rounded up with the palms of the hands and fingers, as well as runner and riser heads. Broken parts are mended better and safer with the finger than with the trowel, loam is daubed on by hand, small patterns are lifted out by the fingers better than with spikes; in fact, the hands of a moulder are of exceptional use to him.

There are two types of rammers employed, the "pegging" and the "flat rammer," and each is used in different sizes. *a* (Fig. 54) shows a pegging rammer, and the size of the flat end piece by which the sand is punched may vary from 1 in. by ½ in. to 3 in. by 1 in.; *b* represents a modified form *a* being capable of going into narrower spaces than *b*. For ramming between

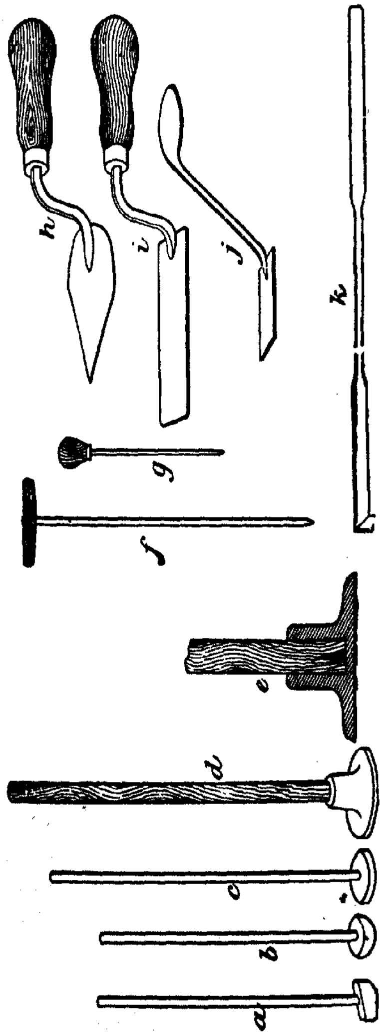

FIG. 54

very narrow spaces, such as the teeth of small gear wheels, and for small cores, a simple round rod of iron is often used. The bulk of the work is done with these pegging rammers, *c* being reserved for finishing off the sand to an approximately level face with the face of the flask or pattern, as the case may be, and for levelling beds.

The flat rammer *d* represents the largest size used, ranging from 5 in. to 6 in. diameter; and is fitted with a wooden handle, the others having iron handles. It is used for going over the largest surfaces and for filling in the sand around boxes placed in foundry pits. The handle is self-wedging, as shown at *e*; the hole being tapered, the head of the wedge touching on the bottom of the hole drives the cleft handle outward, filling up the enlarged tapered space. On the proper use of the rammer depends in a large measure the successful issue of the work in hand. Ramming must be done wisely, with due regard to the character of the mould and the position of the section which is being rammed.

Molten metal always has a tendency to fly off from a hard surface, because the gas generated from the moisture present cannot get away readily, but forms a cushion between the metal and the mould. In a hard rammed open sand mould which is not vented, the gases will be seen bubbling up through the iron, giving rise to little jets or fountains of metal. In a closed mould, the bubbling of the metal against a hard surface from which the air cannot escape with sufficient rapidity will break away the sand in patches, causing scabbing. In chilled moulds, not properly dried and warmed, the metal will blow out. For this reason, a green sand mould should always be rammed only as hard as is necessary to sustain the pressure of metal. The pressure of metal is always greatest on the bottom, and when the depth becomes very great, dry sand moulds are preferable for this reason. But with green sand moulds of moderate depth a hard bed is necessary to withstand the pressure of metal, and then the practice is to ram a hard bottom stratum, and over this a thin stratum of softer and more open sand. Bubbling at the surface is thus prevented, as the gas gets through the more open sand into the denser body or backing below, which is well vented, the venting being proportional to the hardness of the bed. In the case of a thin shallow casting, soft ramming at the surface is of more importance than in a deeper one, because in the former case there is little counter pressure exerted by the metal tending to drive the gas downward. Harder ramming may be done in the top of a mould than in the bottom, because any pressure exerted there is relieved at once by the risers, while that in the bottom is constant.

At the sides of a mould, again, the ramming may be harder than at the top or bottom, because the gas can escape readily. In any case, the harder the ramming, the more complete should be the venting, and care should be taken when ramming to punch the sand, not the bars or lifters or rods. This would disturb and crack the sand, and possibly cause it to fall out of the mould. Neither should the pattern be struck by the rammer, since that means undue compression of the stratum of sand in the immediate proximity, with a resulting scab at that place.

The vent wire is another moulders' tool of the first importance. Small vent wires of $\frac{1}{8}$–$\frac{3}{16}$ in. in diameter are represented at *g* (Fig. 55); large ones of $\frac{1}{4}$–$\frac{3}{8}$ in. being shown at *f*. Since the latter are long and large, they require the use of both hands to drive them through the sand, and hence they are provided with a cross handle. Only in the case of some special work can venting be dispensed with, the exceptions being, for the most part, loam and open sand moulds; but all green and dry sand moulds are vented. The necessity for venting lies in the presence of air in the mould and of gas generated by the decomposition of moisture in the sand. The amount

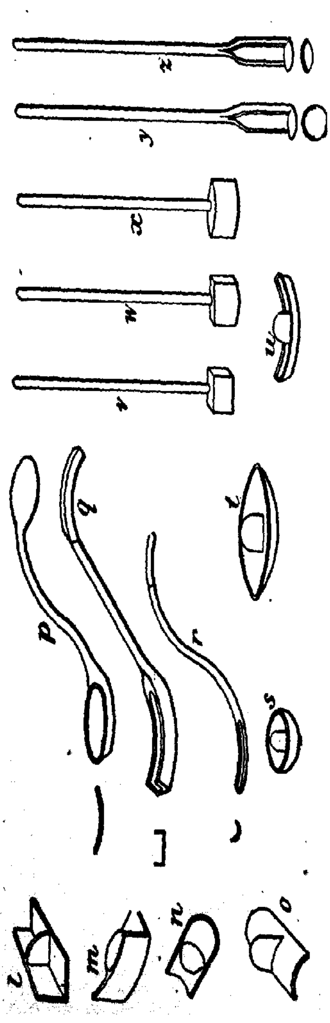

FIG. 55.

of gas thus produced would astonish any but a moulder or a chemist. So soon as a mould is poured, from every vent in the top, bottom, and box joints issues the hydrogen, which, when fired, burns in long lambent tongues of blue flame, and continues to burn for half an hour or an hour, according to the size of the mould. There is enough gas thus carried off quietly and safely to blow up the mould a great many times, if that were desirable.

The presence of a few blow holes in castings will often cause them to be condemned, yet these are due to the confinement or entanglement of some extremely small portion of gas, some few ten-thousandths perhaps of that which has escaped through the vents. Hence the necessity for allowing full provision for the rapid and complete exit of the gases generated within the mould. Of course the vent wire is not the only means of venting employed. When large masses of sand, both green and dry, have to be vented, it is usual to ram up a central portion of ashes as a reservoir for the air, which rushes off in large volumes. These ashes must not be too close to the faces of the mould, especially where there is much liquid pressure, since the sand would be apt to yield there, and produce lumpy castings.

In the case of many dry sand cores, ashes not only afford a good vent, but allow the core to yield to the shrinkage of metal. As to the manner of using the vent wire, there is no need that it should touch the pattern. The practice of moulders differs in this respect; some cover the pattern with pricker holes, while others, who are more careful, scarcely leave a mark thereon. Of course, when the wire touches the pattern the vent has gone far enough; but a careful moulder, when the nature of the work admits it—that is, when the distance from the face of the sand lying outside to the face of the embedded pattern is pretty regular, as in work having tolerably flat outlines—will gauge the distance by first touching the pattern with the wire, measuring the length, and then pushing the wire in to a distance $\frac{1}{4}$-$\frac{1}{2}$ in. less, as required. The reason why this space can be left is that the porous nature of the sand allows the gas to strike through the thickness intervening between the termination of the vent and the face of the mould.

For this reason, also, sand of a close texture and rammed hard requires more and closer venting than a free and open sand. When, as in bedded-in moulds, the vents are driven from the bottom face downward, the surface is always rubbed over with sand to close the openings of the vents. If this is not done, the metal gets into the vents and chokes them up, producing a scabbed, if not actually a waster casting. The distance between the termination of the vents and the face of the mould will depend altogether upon the nature of the work.

The heavier the work, the greater the thickness of intervening sand, because the pressure tending to force the air through is greater; but in very thin, light work, it is necessary to bring the vents close to the surface. Sand which is overdamped will require more venting than drier sand, because obviously there is more gas generated. For close and hard rammed sand, abundant venting supplies in an artificial manner that freedom of exit for the gas which the sand itself, through its density, fails to provide.

The connecting together of the vents in a mould is done in several ways. There is the vent pipe, which connects the vents going down to the coke bed with the outside of the mould. There are the vents from the bottom of the drag in turned-over moulds, which connect the vertical vents from the lower mould face with the outside of the flask. There are the vents from the upper mould face coming directly through the cope; and, lastly, the vents coming out at the joints of the flasks, and bringing off the air from the mould sides. In cases of the latter kind, though the vents or "gutters"

may be put in at random, there is, presuming no closing up of their openings takes place, a certainty that the air will strike through, because the mass of sand has already been honeycombed with the smaller vent wires.

The trowel (*h i j*) is a tool which is constantly in use, doing duty for a variety of purposes, and being carried, like the carpenter's rule, in the trousers' pocket, ready for immediate service. In company with the moulder's hands, it shares the shaping, mending, and finishing of moulds, and is just as serviceable as its namesake used by the mason and bricklayer. It is employed for cutting, digging up, and loosening the sand in small masses; for patching on portions which have become broken down; for smoothing and sleeking over the flat surfaces of moulds, and for smoothing down the blacking and plumbago (graphite) whether used wet or dry; while the butt end of the handle is improvised for thrusting in nails used when mending up. The trowel even becomes a sort of rough gauge, for the moulder usually tests the closeness of the joint of a pattern, or flask, or core, by attempting to thrust in the blade of his trowel. If the blade passes in, the joint is open; if not, there is not much the matter. Again, he marks the outsides of flasks with the trowel, chalking the sides of the flasks and drawing 2 or 3 lines from one across to the other, and when the flasks are finally closed for casting, the coincidence of the lines indicates coincidence of the mould joint within. Again, for pressing down or "pinning" the joint edges of moulds, and so preventing crushing, the trowel is always used, as it is for scraping out core prints when too small for their cores, and for cutting vent channels or gutters, making good the joints of cores and drawbacks, and for a multitude of kindred uses. *i* (Fig. 54) shows the common form of trowel, averaging about 5 in. long. This is called the "square" trowel, distinguishing it from the "heart" trowel *h*. *j* illustrates a combination trowel called the "heart" and "square," which is used only as a touching-up and finishing tool, being made in smaller sizes than the other.

The remaining figures represent tools which are all used for cleansing, mending, sleeking, and finishing moulds. They are called by different names, though their functions are essentially similar, the names being derived from the more especial uses to which they are applied, or to their fancied resemblance to common articles. *k* is the "cleaner," a tool which ranks next after the trowel in point of general utility. Its long thin blade is used for cleaning and smoothing the vertical faces of the deep and narrow portions of moulds into which the trowel would not reach, for mending up similar sections where the fingers cannot enter, for boring holes in moulds for chaplet stalks, and for core vents; while the turned-out foot, standing at right angles with the end opposite, is used for lifting out sand which has fallen into the bottom of deep narrow moulds, for mending up and making good damaged parts similarly situated, for pressing sand around cores after they have been placed in their prints, and for many similar purposes besides. These cleaners are made in widths of blade ranging from ½ in. to about 1½ in.

All the remaining tools (Fig. 55) are finishing tools. Taking them in order, *l* is a square corner "sleeker," or "slicker," or "slaker," or "smoother," and is used for sleeking the internal faces of moulds which stand at right angles with each other. *m* is a tool of the same character, but having one face curved for sweeps. *n* is a head tool, used for sleeking the hollow impressions left by heads. *o* is a hollow head, by which the rounding edges of moulds are finished, or those edges which become the "hollows" of the casting. All these are made in several sizes, large and small as convenient. *p* is a spoon tool, the shape of the bowls resembling those of spoons,

They are handy for finishing hollow work. The head tool *r* differs from the spoon tools in being narrow, parallel, and quicker in curve. It is used for cleaning and finishing heads in circular and hollow work. *q* is a tool differing from the last in having square edges, which sufficiently indicate its use. *v w x* are flange tools, being used for smoothing the bottom edges and sides of flanges and flange-like moulds. *y z* are boss tools, *s* is a button sleeker, *t* is a pipe sleeker, and *u* a modification of the latter. All the tools in this group are made in different sizes, and some in modified forms, and all alike, either in iron or in brass. They require to be kept clean, and free from rust and dirt. For special work other tools besides these are made. The most convenient box in which to keep these small tools is a plain open one with a bridge of iron screwed across the top, by which to carry it from one part of the shop to another, as required. ('Industries.')

MUSICAL INSTRUMENTS:

REPAIRING PIANOS, HARMONIUMS AND MUSICAL BOXES.

Pianos. *Putting in a New Wire.*—The breaking of a wire is a common happening even with comparatively new, sometimes quite new, instruments. It does not indicate any want of quality or poor workmanship, but is caused by either a latent defect in the manufacture of the wire, or in its molecular structure, this probably being brought into evidence by a little overstraining. Hinges, too, are apt to give way before the instrument is otherwise worn, and therefore require renewing sooner or later. It is desirable to be prepared for such casualties, and to provide a cheap tuning hammer, such as may be bought for 1*s*., and a few of the treble sizes of steel wire, also a small quantity of fawn leather and parchment for the hinges, the whole costing about 3*s*.

To put on a string, the action must be removed, and the broken wire taken out. Even if nothing more be done, this will be a great gain, as the string will generally lie across others, causing the whole to jar. The size of the wire (music gauge) is ascertained by reference to the number written upon the plank at the treble side of the string. In most pianos it will be found that the wire passes round the hitch-pin again to the plank. By this plan, the eye at the bottom is dispensed with. Where an eye is necessary, it will be easier to make what is called a French eye. This is done by bending the wire into a loop and turning the loop end twice round just above. This end is then bent at right angles and cut off about ¼ in. from the twist, which will prevent its running back. The top end is wound in close coils round the wrest-pin, this being hammered down to its proper level before tightening. The wire is put in its position on the bridges and tuned roughly between its two outside notes, when the action

can be replaced, and the tuning finished from its octave below. In pianos where the treble notes are not of good quality, or where the strings are continually breaking, considerable improvement will be effected by renewing the top octave, the increased brilliancy obtained by this means well repaying the trouble taken.

Repairing Sticker-Hinge.—To repair a broken sticker-hinge, unscrew the button from the damper wire. The sticker can then be separated from the lever to which it is glued, and removed from the action. The old hinge is then picked from the slot and from the hammer butt. For the new hinge cut a piece of fawn leather rather larger than the finished size. Hammer it to a sharp bend at the middle, which just touch with thin glue, and press into the slot with a blunt table-knife. The hinge is then trimmed to its proper size, and the damper wire passed through its socket. In gluing to its place, avoid being too liberal with the glue.

Re-hinging Levers.—To re-hinge a lever, damper, or hopper: One portion of either of the two first will be found adhering to its rail. This must be detached with sufficient care to avoid tearing the wood; a hot iron then applied to the part immediately above the broken hinge will destroy the old glue, and permit the groove to be sprung open (not entirely separated), so that the parchment may be removed, and a new piece inserted. The joints are then pressed close with a small screw or tied round with thread until the glue is set, any superfluous glue being previously removed from the hinge.

Centres Sticking.—Centres sticking nearly always arise from damp, but with the exception of the keys, is happily not of common occurrence. When it happens with the hammer centres, the only permanent cure, other than removal to drier premises, consists in taking the entire action to pieces, and broaching the centre cloths; but this is so difficult of execution that few, even practical hands, would care to undertake it. When a heavier touch is not objected to, a remedy has often been found in gluing small pieces of weighted pine at the back of the stickers, sets of which are sold expressly for this purpose.

Keys Sticking.—Keys sticking are remedied by slightly easing the front hole with a small flat file, care being taken to remove only sufficient wood to take away the pin mark. To test if the key also binds in the centre, lay the key so that the centre pin just enters the countersink of the round hole, when its own weight should be sufficient to cause it to sink to its proper position. If it does not do so, the centre square hole also requires easing; the round hole rarely needs altering. Keys will also occasionally stay down where, in consequence of the frame warping, the front pin is out of the hole. This can be detected by the mark; where, on the contrary, through hard service, the keys have become loose, and rattle, a new and larger set of pins may be substituted. This will be found quite as easy to do, and a much more effectual remedy than wedging the holes.

Blocking.—Blocking is caused by the hoppers not "setting off." The effect of this is most unpleasant, as the hammers then block or jam against the strings, and deaden all vibration. The regulating wire in the hopper should be unscrewed about half a turn, so that the hopper slips from under the lever just as the hammer reaches the strings. Where the blocking is accompanied with a creaking noise on the keys being pressed down, it is the effect of damp, and on examination it will be seen that the top of each hopper has become rough through the softening and consequent abrasion of the blacklead (graphite). A little of this applied damp with a small leather pad, and afterwards burnished with a piece of smooth steel (such as the barrel of a tuning hammer), will put matters right. Where the blocking

occurs from the check of the hopper, the touch is too deep for the blow, and a piece of brown paper should be put under the baize at the front of the keys.

Moths.—Of all the ills to which a piano is liable, the effect of moths and moisture are the most disastrous. Of the two, the former is perhaps the more destructive, because the attacks are more insidious, and the mischief is generally very far advanced before it is discovered. There is no part of the action, however small may be the aperture, that will escape the ravages of the grub, and many a fine instrument has in a short time been converted by them into a complete wreck, and even after a thorough repair and supposed complete extermination of these pests, the destruction will often recommence; so that wherever there seems reason to suspect their existence, the most rigorous examination and cleaning of all parts of the interior is imperative. A saturation also of the suspected parts with spirit and camphor has often been found productive of good effect.

Damp.—To guard against damp, it is advisable that a piano should never be placed, if it can be avoided, on a stone floor or close against an outside wall. Where this is impossible, it is better to raise it either on a thin wooden partition or on "insulating" glasses, so as to allow a passage of air all round; also occasionally removing the front, and where the hammers seem inclined to stick, place the action at a little distance from the kitchen fire. Other symptoms of damp, and the way to cure them, will be noticed farther on.

Durability.—Pianos that have been made within the past 20 years or so are, both in frame and mechanism, of much greater durability than those of earlier date. In the latter, among other shortcomings, the action centres were so tender, even when comparatively new, as to require the greatest care in handling; whereas, in the more modern instrument to effect a casualty would take an amount of force not likely to be exercised, so that with common care the different parts may be taken asunder without the slightest risk. As a rule, the public are slow to appreciate this, and the old fear of meddling with any portion of the interior still exists. With the harp, on the contrary, one of the first lessons a purchaser finds it necessary to learn is to tune it, and replace broken strings, and it would be considered quite exceptional, even for a lady, not to possess this amount of skill. It may fairly be urged that as the tuning of a harp is diatonic, and the strings so much more accessible, there is little comparison between the two; but it must also be remembered that though the tuning of a piano, as a whole, may be, and generally is, beyond the powers of an amateur to accomplish, there are yet many accidents to which the mechanism is liable, which, though trivial in themselves, are not on that account the less annoying (especially when it happens, as is often the case, where the visits of a professional tuner are few and far between), and yet are very easily put right—such an occurrence, for instance, as a crumb or other small article getting between the keys will occasionally render a piano useless, and necessitate, besides delay, the expense of a tuning, when probably it would not otherwise require it. How often the simple breaking of a wire has a like effect most readers know to their cost.

Taking to Pieces.—In upright pianos the whole of the movable parts are kept in their places by what are termed steady pins, so that when replaced they are certain to be in their exact position for playing, and as the first step in repairing is to obtain access to the interior, the beginner should accustom himself to take all these to pieces until he is familiar with the mechanism. To take out the doors, having turned back the buttons (if any), pull them forward at the top, and then lift them up off their bottom dowels—in replacing, these movements

are reversed—the cylinder and hollow can then be lifted out, the left hand holding the cylinder, and the right placed under the back of the hollow. The action is removed by pulling it forward at the top, and lifting out by the hammer-rest; where the dampers are detached it will be easier if they are first taken out. In replacing, it is necessary to be careful in guiding the back of the action over the hoppers, and in placing the dowels at the bottom of each standard in their respective holes, when, by a slight pressure at the top, the action will slip into its place. In pianos that are fitted with a double check action, the *modus operandi*, though still the same, is a little more difficult of execution, in consequence of both the weight of the action and the complication of its parts, but generally in such instruments special directions are pasted inside to serve as a certain guide. Keys may be taken out by lifting them at the front until they are clear of the centre pin, when they may be drawn forward. In practising these movements, it must be borne in mind that under no conditions should force be exercised, as every part should drop easily into its place.

Keys.—Lime-wood is generally used for keys, though any straight-grained and tough wood would answer quite as well. When the middle of a wide board is used, the keys at that part are liable to warp, and sometimes to twist. A slight warping may easily be cured by laying the hollow side of the key on a flat-iron, and gently striking the upper side with a broad faced hammer, between the centre hole and the hopper, the key being bent, by a pressure of the hand in the direction required. If the warping is very bad, it will be necessary to wedge saw kerfs about ¼ in. deep in the hollow side, though this requires great care, as the key is apt to break. A twisted key is very hard to straighten, as the saw kerf will have to be diagonal, and a wrong slant will only make it worse. A great deal can, however, be done with the plane, and by resetting the hopper or by bending the key pin. Pine makes a very good key, when slipped at the pin-holes with a hard wood.

Hammers Sticking.—In all problems relating to the repair of pianos, it is not so much the cure as the cause of a defect that is difficult to discover, for when the latter is once known, the remedy is generally easy enough. Properly speaking, a hammer can only stick from its centre; but a damper wire out of place or binding in its socket, a hinge-bound sticker, or a broken tape to a check action may each be described as a "sticking hammer," although the hammer itself may be perfectly free. It is so common to see a set of centres completely ruined by unnecessary broaching that it is worth while taking some trouble to first ascertain whether the centre is too tight or not. It is pretty good evidence that the sticking is caused by the damper wires when the hammers are free at the treble end, but this will be rendered more conclusive by bending one of the wires out of its socket and trying the effect. If the hammer is then free, it is the socket rail which must be broached; but if the hammer still sticks, it must be either that its centre is tight, or the butt of the hammer is jammed between the forks of the rail. To test for the latter, insert the point of a pen-blade between the fork and butt, and whilst there work the hammer to and fro with the finger. Should this not succeed, there is nothing for it but removing the wire and broaching the centres; but this is altogether too difficult a task for any amateur to attempt. Dampers are often kept from the strings by hanging upon their lifts. If upon the damper wire lift, screw down the lift (or button), until there is the space of a card between the lift and damper. With Collard or Kirkman dampers, they may also hang upon the rail lift, or the piece of wood which lifts the dampers when the loud pedal is down. Either of these makes may be eased by enlarging the screw holes and lowering

the lift, though for Broadwood or French dampers this is not needed.

Pitch.—It is useless to keep tuning up to pitch, until the cause of giving way is remedied. The causes are various. If the wrest plank has not been thoroughly seasoned, it would cause the pins to give from the immense strain on them. The same remark may be applied to that part (at the bottom of the piano) where the hitch pins are inserted. Instances have occurred where the hitch pins have been torn through the wood from the strain on them. If the scale or speaking length of string between the belly bridge and wrest plank is not to the correct length, it will cause a breakage of the strings, and the instrument cannot be kept up to the standard pitch. A good many pianos become worthless from the inaccuracy of their scale. Now for the remedies: To cure looseness of the wrest pin in the hole, if the wrest plank be sound, put a larger rest pin in. When the hitch pin does not hold in the bent side or bottom block, if the bent side or bottom block is sound, replace either with a stouter or longer hitch pin. (W. H. Davies.)

Buzzing.—"Buzz" is the most important of the minor defects of a piano, as it is generally also the most persistent. The conditions under which it may occur are various, and for the most part, simple and easily removed:—

(*a*) Shavings may have been left in the bottom of the case or at the lower ends of the wires, and will be seen on removing the lower panel, i.e. the one below the key-board.

(*b*) The cause may be found in a loose fit of the upper or lower panel, or of the fall, or of the bar upon which the fall rests, or of the lining under the key-board; or the fall may not truly lie back when opened, or the lid may not rest evenly upon the sides and front. Any defect in the fitting is sufficient to cause a buzz.

To discover the cause: first raise the lid. If the buzz ceases, the cause lies in the fitting of the lid, which must be adjusted by raising or lowering one, or both, of the hinges at the back. If not, remove the upper panel. If the buzz ceases then, find out what part of the front causes it. The panel being replaced, the buzz will probably again be heard: it may happen that by merely taking out the panel and putting it in again the defect in the fit has been remedied. If not, the part whose looseness causes the buzz, will be found by pressing the panel in its frame, or the frame itself downwards, inwards, outwards, or sideways, until the disagreeable noise ceases. It is possible that a piece of ordinary writing paper gummed or glued on at the spot, where pressure has stopped the buzz, will be sufficiently thick to produce a perfect fit. If the manipulation of the front does not bring about the desired result, proceed in the same manner with the lower panel, the keyboard lining the fall, and the bar on which the fall rests. The fall is removed by simply raising it: if the fit is perfect, this is not easily removed. The bar beneath is fixed by a sunk screw at each end to the frame of the piano. The keyboard lining is usually sprung into position, wedging itself into the slits which receive it, and the defect will be an imperfection of the wedging. A thin slip wedge is the remedy.

(*c*) Torsion of the sound-board may arise from the woodwork adjoining the iron studs which, when the lower panel is removed, are visible at the base of the piano, projecting through the sound-board. This is originally cut away just enough to admit the passage of the studs without contact. These studs, however, have a very sharp rise, and it may happen that the tension of the strings produces in the lower part of the board a certain amount of torsion, and very little suffices to bring the two into contact. When this takes place, a buzz results. The remedy is obvious, by means of a thin narrow sharp knife.

(*d*) Great difference is to be noticed in the tone of different pianofortes, and even of different notes on the same

piano. These differences are largely dependent upon the material of the frame and bridging; and it may be said broadly that *cæteris paribus*, the tone will vary between sharpness and shortness, and softness and rotundity, according as metal or wood predominates. But quite distinct from these qualities, accidental to the material, is the clearness of note given by a perfect instrument, the result of effective toning. The operation is simple, but delicate in the extreme, and the affected part is the felt covering the hammers. This felt which is of a very fine kind, varies occasionally in density and this variation may sometimes produce a buzz. An operation which improves the quality of the tone, and removes the buzz (when attributable to the cause under consideration) by equalising the density, consists in pricking the felt on the upper part of the hammer with the toning tool, which, in its simple form, is a fine steel fork of 3 short sharp prongs. The felt is not perpendicularly prodded, but the points of the fork are stuck into the felt as often as is requisite to produce the correct tone, and in the direction shown in Fig. 56, the motion

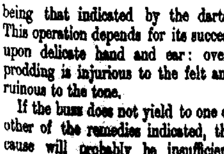

FIG. 56.

being that indicated by the darts. This operation depends for its success upon delicate hand and ear: over-prodding is injurious to the felt and ruinous to the tone.

If the buzz does not yield to one or other of the remedies indicated, the cause will probably be insufficient tightening of leading screws, or defective fixing of the foundations, or imperfect gluing, and the instrument must be handed over to a pianoforte-maker.

Faulty Repetition.—Another common defect is in the "repetition"; a key will not rise to the level instantly the finger is raised, it rises either slowly or not at all. This may result from one of two causes; either the key has warped or it has swollen.

(*a*) The warping of the key will probably be the result of the piano having been subjected to extremes of temperature—great heat in summer, and great cold in winter; or perhaps one day the room is without warmth of any kind, the next it has a roaring fire. In time the keys will stick. To remedy this, raise the lid and remove the front, the fall and the bar, raise the key by the forepart, above the pins which keep it in position, and draw it forwards. Where the key rubs its neighbour it will generally appear chafed, but if no chafing is apparent, just rub the side lightly with black-lead, and replace the key—it will now blacken its neighbour at the point of contact, and at the corresponding part of itself it may be rubbed down very slightly with glass-paper, first No. 1, then No. 0.

(*b*) Swelling of the key is the result of damp alone, which operates by decreasing the size of the holes into which the fixed pins fit, and these are accordingly more or less gripped by the key. Perhaps only one is tightened, more likely both. On taking the key out, it will be at once apparent whether both pins are gripped or only one, as the piece of cloth in the forward hole, and the wood itself in the case of the other are dented and blackened. The hole may be enlarged to the necessary extent by shaving the wood with a fine penknife, but preferably by filing it with a fine fret-file of oblong section. No more should be taken off than is just sufficient to enable the key to work freely, as otherwise the key will rattle and work unevenly.

There are some external causes of "buzzing" which demand attention. Thus the piano may be standing on a loose floor-board: the remedy is to fasten the board tightly with screws,

removing the loose nails, or hammering them well in. Glass in pictures, mirrors, windows, doors, etc. may be loose or cracked; also gaselier globes and candle-chimneys. The remedies are tightening or placing a piece of cloth between the glass and its support. China ornaments, for a similar reason, should rest on or against a deadening material. The scuttle, fender, and fire-irons also require looking after to prevent jarring. Nothing should rest on a piano while it is being played. If candlesticks are necessary, their feet should have baize glued on, or they should stand on mats.

Renewing Pins and Wires.—As the pins and wires of pianos become worn, it is necessary to renew them. First remove the action—the apparatus which sets in motion and includes the hammers. Raise the lid, take out the front by undoing the little button at each end of the top, drawing it outwards at the top, and lifting it from the pins in the upper edge of the fall. Then remove the fall, and the action is fully exposed. Before removing it, observe whether the dampers do or do not form part of the action. If the wire which passes up between the "stickers" (upright rods which set the hammers in motion) goes through the head of the damper and is secured at the other side by a nut, and if the dampers have no independent frame working in its own sockets, as may be known by moving the right pedal, the dampers cannot be taken out separately. Those having such a frame will work in a socket at each end, or a socket at one end and an eyelet-hole on a screw at the other. Turn the buttons and lift up; or turn one button, raise that end, and draw out of the eye.

Fixed to the inside of each end, and 6-8 in. from the top, is a block carrying a button, which keeps in position the upright bars forming the ends of the action frame. Turn these buttons, draw the upper part of the frame outwards, and then lift upwards and outwards bodily. The action is delicate part, and at the same time heavy, and to remove it without an accident requires firmness and carefulness to exercise equal strength at each end. The slip lying across the keys will be removed by unscrewing at each end, and the keys can then be raised. The keys are all numbered, and it will save much time in replacing, if they are put aside in an orderly way.

To substitute new or replace the old pins, the piano should be laid on its back, and this may as well now be done. The pins are slightly roughed on the part which lies in the head-piece; as this roughness is screw-like, there will be but little difficulty in extracting them. To remove a pin, first turn it sufficiently to relax the string. This can most conveniently be done with a tuning key, but a strong pair of ordinary pincers may be made to serve. When turned enough, remove the string, and then extract the pin with the pincers, turning to the left and drawing out.

It is possible the old pins will do with a little help, in case it is not easy to obtain new and larger ones. Take out one of those belonging to each note of an octave in the most-used section of the instrument. Thoroughly dust the sides of the holes with dry finely-powdered chalk, replace the pin, and hammer it well in to the proper extent, i.e. up to the head or blackened portion. The great points in repinning are to drive the pin in perfectly perpendicularly to the head piece, and to drive it well home. The little hole in the pin should be perpendicular to the base line of the piano. As it is of paramount importance that the pin should fit very tightly, it will require the exhibition of not a little well-directed strength to do this properly, but there is nothing really difficult in it.

The removal of *one* pin to a note will be quite sufficient in the case of a trichord or semi-trichord piano; but care must be taken to remove corresponding pins in adjacent notes by which is meant the pins bearing the ends of one string. Thus in Fig. 57, which suffi-

ciently shows the system of stringing, the pins marked represent those to be removed. In a bichord, both pins

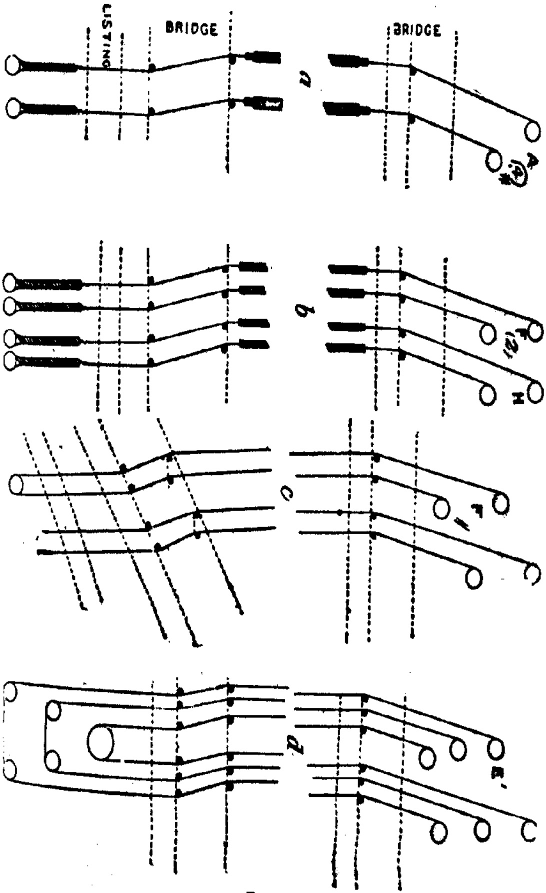

FIG. 47.

must be removed, as the one string furnishes the 2 chords. If the chalk answers its purpose, the string kept by the pins thus treated will remain in tune while the other strings are affected. The difference will first become sensible by a vibration being audible on the one note, and the remedy will be proved by the differ-

ence in pitch on damping the wires in succession, and striking the note if the difference between the number of vibrations of each string is sufficient to be separately appreciable.

In the illustration, *a* is a monochord double-covered string; *b*, a bichord single-covered string; *c*, a bichord plain wire; *d*, a trichord plain wire.

Pins are made in 6 sizes. Hughes, 37 Drury Lane, sells complete sets of the ordinary size ("02 A") at 1*s*. 8*d*.; and of the largest size ("0000 A") at 2*s*. 6*d*.; for numbers less than a set, 4*d*. per dozen.

The pins being fixed, put in the wires. Of these there are 3 kinds: double covered, single covered, and plain; the first-named being for the lowest bass notes. All the covered ones are fixed singly; each chord is a separate string. The plain ones are fixed one to a note in a bichord, or the bichord portion, and 3 to 2 notes in a trichord. The course of the strings in each case is shown in Fig. 57. Care must be taken that the wires properly traverse the bridges, and are caught by the right pins, which are intended to shut off the part not intended to vibrate from the free part on which the hammers act. The wire is then drawn through the little holes in the wrest pins as taut as possible (a sufficient length in the case of the plain wire being cut off the roll), and given a turn to secure it from slipping. It is then tightened up with the key, and finally tuned. It will have been noticed that below and above the bridges are pieces of braid, flannel, or listing running in and out of the wires. These are very necessary, and serve to deaden the part of the wires beyond the bridges. Just below the line of wrest pins should be figures to indicate the size of the wire used; for all notes between any 2 of these numbers, the size indicated by the lower is to be employed.

The wire, in bulk, is sold by the pound, for which weight the price is 2*s*. 6*d*., whether plain steel or covered. The latter kind is also sold by the single string, from 4*d*. for the thinnest to 1*s*. for the double covered.

Rusty Wires.—Wires are frequently found to accumulate rust. This arises solely from damp, either a damp atmosphere in the room generally, or damp ascending from the floor. The latter may be checked by covering the floor beneath the piano with a sheet of waterproof paper, either Willesden paper or ordinary brown paper well dried and coated with linseed-oil varnish on both sides, laying it under the carpet.

To remove rust from the wires, rub them lengthwise with a piece of fine chamois ("shammy") leather with emery flour or crocus powder spread on it, thoroughly removing every particle of the powder afterwards with a clean leather.

Celeste Pedal.—To soften the tone of a piano, use is made of a pedal action which shifts the hammer so that they strike less wires—1 instead of 2 in the bichord, and 2 instead of 3 in the trichord. By the Celeste method, the hammers strike always the same number of wires, but the softening effect is gained by interposing a layer of felt between the hammer and the wire.

On taking away the upper and lower panels and the action frame, and supposing the remaining fixed part and the right pedal lever removed, there are only the back, body, strings, and soft pedal lever left. At the back of the action frame runs a strong board, which keeps the stickers and hammers in position. This is held firm by a strong spring at the right end, and at the left end will be found a lever, whose lower left end rests on the upper end of the upright rod which springs from the side end of the pedal lever, while the upper end of it fits into a notch cut in the board. When the pedal is depressed, the rod is raised, and the board is pressed sideways. With the Celeste, this square lever is no longer required; it is unscrewed and removed.

For fitting with the Celeste pedal, 2 pedal levers are required, in order to

support and work the 2 side rods that carry the lath to which the felt is attached. One pedal has to draw down both levers, so that the division between them must be shaped accordingly. The ends where friction occurs are covered with baize, and then rubbed with yellow soap. Generally the height of the side rods is determined by the height of the hammers. The damping felt is 1 in. wide at the treble end to 1⅛ in. at the bass end, and 1¼ in. is glued on to the lath. The length of the felt is just a trifle over what is sufficient to cover the wires. The lath is 1¼ in. deep and a ½ in. thick, and fits into a slot at the upper end of each side rod, so that the top edge of the lath is level with the end of the rod. The side rods rest on the extreme ends of the pedal levers, to which they are attached by leather hinges; the mode of attachment will best be observed from the discarded side rod, which will be too short for use. These rods must run up quite close to the side walls of the piano, and their length will be such that the upper edge of the felt will rest ordinarily 1 in. below the line on which the hammers strike the strings. At about 6 in. down, a mortice is cut in each rod, and this works on a 1¼ in. screw, driven into the side wall. The length of the mortice is such, that when the pedal is down, and the rods are raised, the felt will cover the line on which the hammers strike the strings. A small circular felt washer lies between the rod and the head of the screw. A strong band spring attached to the under side of the right lever, and acting on the floor of the piano, completes the mechanism. (W. W. C.)

Harmoniums.—*Parts of, and to make.*—First purchase about 16 ft. of ¾-in. pine, about 1 ft. wide, and a plank of good sound beech, 3 ft. long, 7 in. wide, 2 in. thick at one end, and and running off to ½ in. thick at the other. Be particular as to the quality and soundness of the wood; it must be thoroughly well seasoned; and, in order to ensure its being thoroughly dry, kept in a warm room—but not too near a fire—for some weeks before being worked upon.

While the wood is drying, procure your vibrators or reeds, from any harmonium-builder. Buy a good set of 54 notes, C C in the bass to F in the treble, being 4½ octaves. Prices of reeds run from 12*s.* 6*d.* to 25*s.* a set, according to quality; reeds can be purchased, together with leather for the bellows, and all other requisites, of Willis, 29 Minories. Also purchase the screws (about 15 dozen) for screwing the reeds to the sound board. See that the reeds are well riveted, or they will soon get slack, and cause much trouble.

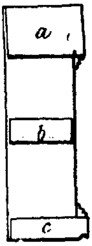

FIG. 58.

Fig. 58 is an elevation of the ends of the case; *a*, block or cheek; *b*, ledge; *c*, bottom block; *d*, groove for front panel. Fig. 59 shows under side of boards to carry feeders; Fig. 60, valve boards for feeders; Fig. 61, shape of pieces for sides of feeder; Fig. 61A, shape of pieces for ends of feeder; Fig. 62

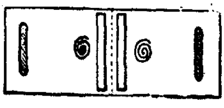
FIG. 59.

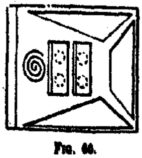
FIG. 60.

pair of ribs (black line at top shows where linen is glued on). Fig. 63 illustrates the arrangement of the interior: *a*, feeders; *b*, reservoirs; *c*,

wind-chest; *d*, spiral springs; *e*, supports for crank; *f*, cranks; *g*, cords for connecting ends of crank levers

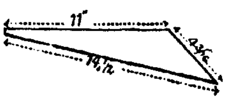

FIG. 61.

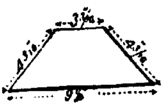

FIG. 61A.

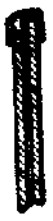

FIG. 62.

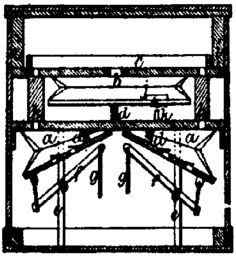

FIG. 63.

to foot-boards; *h*, wind-trunks; *i*, blocks or cheeks; *j*, safety valve; *k*, peg to open valve.

The Case.—The case must be got ready first, as the bellows and other parts are fitted to and supported by it. The wood may be pine, oak, mahogany, walnut, or rosewood. First make the ends, 2 ft. 7 in. high, about 12 in. wide in the narrowest part, and ½ in. thick. The top portion, to a depth of 7 in., projects about 2 in. at the front. This wider portion must be thickened by gluing and screwing a prepared block, 2 in. thick on to the inside. The bottom part should also be blocked out to the same thickness, and 3 in. in depth. These blocks need not be solid, but may be made of ¾-in. stuff, and then veneered over where they will be in sight. An ornamental truss may be placed under the front of the top block, or cheek, or a turned pillar may run from the under side of the top block to the top of the bottom one, which will form a base for it. Now glue and screw a ledge of wood, ¾ in. wide and 3 in. deep, to each end, to support the bellows. These ledges, as also the cheeks, should not extend right across the end, but to within ½ in. of the back, so as to allow the dust panel, or back, to be fitted in. A glance at Figs. 58 and 63 will explain these operations.

Prepare a panel of ¼-in. stuff for the front, 3 ft. 3 in. long, and 2 ft. high, with an opening cut in the bottom part, 1 ft. 8 in. long, and 8 in. high, to allow the feet to be placed on the foot-boards. This panel is let into the under side of the cheek or blocks, about ½ in.

Prepare a board 4 in. wide, 3 ft. 4 in. long, and 1 in. thick, and screw it at the bottom of the lower blocks, so that it may come right to the front, and lie flat on the floor. This is the foundation-board, on which the foot-boards for blowing will be hinged.

Take 2 boards, 3 ft. 3 in. long, and fix one to the top cheeks at the back, and one at the bottom.

Proceed to fit up the interior of the case. First prepare 2 boards, 3 ft. 2 in. long, 11 in. wide, and at least ¾ in. thick, to carry the feeders and reservoir. Plane them very true and smooth, then cut 2 holes in each, 6 in. long and 1 in. wide, at a distance of 3 in. from each end. Fig. 59 shows the under side of the board to carry the feeders, with 2 spiral springs fitted to it, and the holes cut in it for the wind-trunks. The springs are to cause the feeder to open when released from the pressure of the foot, and are termed "gape-springs." They may be made by cutting an ordinary spiral chair-spring in half, and placing each half in the position shown.

Feeders.—The feeders next claim attention. The under or valve boards are each 1 ft. 4 in. long, 10½ in. wide,

and $\frac{3}{4}$ in. thick. Bore 4 holes, $1\frac{1}{2}$ in. diameter, through them, as shown in Fig. 60. These holes are to be covered by valves, which must be made as follows: Glue 2 thicknesses of leather together (soft side outwards), leaving one 1 in. wider than the other; place them between 2 flat boards to dry, then cut them to size, and glue the single thickness down to the valve-board, thus forming a hinge to the valve. The valves may each be made to cover 2 holes, so that only 2 valves will be needed for each feeder. They should be $\frac{3}{8}$ in. larger all round than the holes which they cover.

Valve-boards.—The valve-boards are next hinged on to the feeder-board, and for this purpose a strip of $\frac{3}{8}$-in. wood, $1\frac{1}{2}$ in. wide, is to be glued and screwed on to the under side of the feeder-board, and a similar strip on to the inside end of the valve-board. The valve-board may be hinged either with brass butt-hinges, or a strip of leather inside and out. Many prefer the latter mode, as there is no liability to squeak.

Feeder-folds. — The folds of the feeder may now be got out of $\frac{1}{4}$-in. board. You will require 8 pieces like Fig. 61 for the sides, and 4 pieces like Fig. 61A for the ends. The ends of each fold are cut to an angle of about 40°. Set these out very carefully, as it is important that they should be accurately made, or the feeders will be the source of constant annoyance and trouble. Procure some very soft, supple, white sheepskin, and cut it into strips (lengthways from the neck), about $1\frac{1}{4}$ in. wide. Cut some strips of linen, about $1\frac{1}{4}$ in. wide, across the stuff. Stand each pair of ribs side by side, with their short edges about $\frac{1}{16}$ in. apart, which you may secure by placing a strip of stout cardboard between them, and glue a strip of linen over the edges, as shown in Fig. 62. The linen will thus be on the inside when the folds are attached to the feeders. Let this dry, and then glue a strip of leather on the other side of the joint, grain side outwards. Then glue similar strips on the outside of the top and bottom edges, so that half the width of the leather overhangs all round. Fasten the spiral springs in their proper position on the valve-board, and then glue the overhanging leather of the folds on to the valve-board and feeder-board.

The inside must also have strips of linen on the joints, which you will be able to rub down with a strip of wood inserted through the corner holes where the gussets will be put on. When you have attached all the folds to the feeder and feeder-board, and well rubbed down all the leather, to make it adhere perfectly all over, let it dry thoroughly. Open the feeder to its full width, and cut a paper pattern of the gussets; cut them out in leather, and, after paring all the edges with a sharp knife, glue the gussets on, and rub them down well. A small triangular gusset-piece will be required for each corner where the valve-boards are hinged; and if brass hinges are used, a strip of leather must be glued all along the joint, to make it perfectly air-tight. When all this is done, clean off the leather with a sponge dipped in hot water; cover all the woodwork of the feeders with coloured or ornamental paper, and they will look very neat.

Wind-trunks.—Make the two wind-trunks of thin wood, $6\frac{1}{2}$ in. high, and slightly larger internally than the wind-holes.

Reservoir.—The reservoir is merely a rectangular bellows, with each fold $2\frac{1}{2}$ in. wide. Cut the ends of each fold to an angle of 40°, the same as the ends of the feeders. The bottom board of the bellows will be $\frac{1}{4}$ or $\frac{3}{8}$ in. thick, and a safety-valve must be made in it in the position shown in Fig. 63, *j*. This may be about $2\frac{1}{2}$ in. square, and covered by a valve of thin wood, lined with soft leather (soft side outwards), one end of which overhangs about 1 in., and is glued down to form a hinge. The valve is kept closed by a spring fastened through a little staple on the valve. A peg of wood, about

2½ in. high, is fixed in the feeder-board immediately under the valve; so that as the bellows descends, the peg presses the valve open, and allows a little wind to escape, thus preventing undue pressure on the reservoir. A spiral spring is fixed to the centre of the under side of the reservoir, and to the top of the feeder-board. This spring exerts a constant pressure on the reservoir, and gives the force of wind necessary to cause the reeds to sound.

Foot-boards.—The foot-boards may be made of 1-in. deal, hinged on the under side of the front edge to the foundation-board already mentioned, and connected from the top by a cord to the lever arm, which is fixed into an axle working on centres in 2 uprights placed at the front and back of the inside of the case. Another arm extends from the other side of this axle immediately under the centre of the feeder, to which it is connected by a short lug. The general view will sufficiently explain this, the axle there being shown in section only. The foot-boards should have a ledge of ¾-in. stuff on the front edge, and they may be covered with a piece of carpet to make them look neat.

Wind-chest.—The reservoir having been completed, should now be fastened with glue to the reservoir-board, which has previously been referred to. This board lies on the top of the 2 wind-trunks, which should have a strip of leather run all round the top edges to make all air-tight.

The holes in the reservoir-board over the wind-trunks must be covered with leather valves to open upwards, made in a similar manner to those in the feeders. These valves are to prevent the return of the wind after it has been pumped into the wind-chest. A small hole, 4 in. long and 1 in. wide, is cut in the centre of the reservoir-board, to let the wind into the reservoir. If this is covered with a wooden valve lined with leather, so that it may be closed by pulling out a stop knob, you will have the stop termed "expression"; but if you do not wish for this stop—which is rather difficult to manage, and causes the breakage of many reeds by over-blowing—you will not require any valve over the hole, but may, if you like, make it rather smaller, and cut 2 more holes, 1 on each side of the central one, and about equidistant from that and the ends of the reservoir, as shown in Fig. 63.

To form the wind-chest, take some ½-in. pine, ¾ in. wide, and glue it all round the top of the reservoir-board fair with edge of it at the sides, but 2 in. in from the ends, and plane it level all round, thus forming a shallow bow ¾ in. deep. Now to see if your bellows answer, lay a strip of leather all round the edge of the wind-chest, screw a ½-in. board tightly down on to it, and glue some paper all round the joints to prevent any escape of air; when dry fit it into the case, placing a couple of long wedges under the cheeks to hold the reservoir-board firmly, and a screw or two through each end of the bellows board into the ledges. Press the foot-boards gently and fill the reservoir (do not overdo it), and then if your bellows is sound, and the valves act all right, the reservoir will take some minutes to empty itself. This board is only used to test the bellows, and does not form a part of the instrument. It is utterly impossible to make the bellows entirely without leakage.

Pan.—The pan or sound-board next claims attention. Take the beech plank before referred to, which is to be 2 ft. 7 in. long, 6 in. wide, 1¼ in. thick at the bass end and tapering off to ¾ in. thick at the treble end. Plane this very truly on both sides for it must not be touched with the plane after the subsequent operations. Take the width of the row of keys—which will be about 2 ft. 5¼ in.—and mark it on the sound-board, leaving 1 in. at the bass end and ¾ in. at the treble end; divide the 2 ft. 5¼ in. into 54 equal parts, and the lines thus made will be the centres of the mortices, which are set out as follows: At a

distance of $1\frac{1}{2}$ in. from the back edge of the board, draw a straight line all along it; at the bass end, set off $1\frac{1}{2}$ in. from that line on the first of the cross marks; at the treble end, set off $\frac{3}{8}$ in. on the last cross mark, and join it by a sloping line to the bottom of the $1\frac{1}{2}$ in. line, you will thus get the lengths of all the mortices. Then mark the widths of the mortices, which should be $\frac{1}{4}$ in. at the bass and diminishing to $\frac{1}{8}$ in. at the treble. Cut the mortices right through the sound-board, and clear them out nice and smooth; those in the base may be cut back on the under side, as shown by the dotted line in Fig. 64.

Cover the top of the board with a piece of stout veneer—sycamore being the best—which should be glued and clamped tightly down, and, when thoroughly dry, the pallet holes may be cut through it, those at the bass end being 1 in. long and rather more than $\frac{1}{8}$ in. wide, and gradually diminishing in size up to the treble. You can mark these out in the same way as the mortices. Having done this, take some $\frac{1}{2}$-in. beech, or pine, 2 in. wide, and box round the edges of the sound-board fair on top side, the boxing projecting on the under side only. Now get out a bar of beech 1 in. square and 2 ft. 6 in. long, and glue it down on the top of the sound-board, so that the centre of it is $2\frac{3}{4}$ in. from the centre of the pallet holes. Run a deep gauge mark all down the centre of the top of this bar to receive the centre wire on which the pallet levers work. Cut out 54 grooves in the bar in a line with the pallet holes; this may be done by tying two small tenon saws together. Now make the pallets and levers, as in Fig. 64, the levers being made first and bored through the centre with a fine bradawl, or drill. The hole in the end to receive the long thin screw can be best made by screwing the lever lightly into a vice, and the screw can also then be inserted without danger of splitting the wood. The pallets themselves are made large enough to cover the holes well, and are tapered off at the top as shown. They are covered with soft leather on the under side, and whiting should be rubbed into the leather with a little block of wood. In gluing the pallets on to the levers, some place a piece of stout soft leather between the lever and the pallet.

String the levers on to the centre wire, put them into the proper grooves, and press the centre wire down into the gauge mark; then glue a piece of wood $\frac{1}{4}$ in. thick on each end of the bar, with a hole in it level with the gauge mark to receive the ends of the centre wire, which may be drawn out

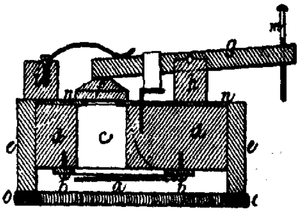

FIG. 64.

from either end if required at any future time. Just at the back of the pallets fasten a strip of wood exactly thick enough to be level with the tops of the levers; this is to fasten the pallet springs in. The springs are made of tolerably stout piano wire, bent into the form shown, the front end being turned up to run in a gauge mark on the top of the lever, the back end turned down and fixed into the strip of wood above referred to; a small screw being inserted close behind it, so that the head holds the wire well down, or a small loop may be made in the end of the spring and the screw passed through that.

It may be of service to mention a plan for entirely dispensing with these steel springs. Bend some pieces of

wire thus ⅂, and insert one between every pallet lever, just behind the centre bar. Then procure from a draper, 2½ yd. of covered elastic band that will stretch well, and, having made a loop at one end, slip it over the first wire crook, then over the first pallet lever, under the next crook, and over the next lever, and so on all through. This plan is simple and answers well; when the elastic does wear out, it can be renewed with very little trouble, and at a cost of only a few pence. The band should be ½ in. wide, and contain at least 6 strands of elastic.

The vibrators may now be screwed on to the under side of the sound-board in the position shown in Fig. 64, and the sound-board may then be considered complete. It should be hung by a peg through each end, which is made to project 3 in. for that purpose, the peg running into the cheek blocks, so that the sound-board may be turned down as on a hinge, and lie flat on the wind-chest. Make a little roll of cloth, cover it with soft leather, and fasten it all round the under side of the sound-board, then fix 2 iron hooks in the side, and 2 eyes in the wind-chest, so that when the sound-board is turned down on to the wind chest, and the hooks are fastened into the eyes, there can be no escape of wind from the wind-chest, except through the vibrators and pallet holes. The key-board will best be purchased, either new or second-hand. When it is placed in position, the screws in the ends of the levers should come under the proper keys, so that when the key is pressed down it opens the pallet belonging to that note.

A folding lid should be made to the case, and hinged at the back edge so that it may be turned right back if required to get at the interior of the instrument. Finish off the case in any style you may fancy, and your harmonium will be completed. If the case is made of mahogany, all that need be done is to French polish the exterior, but if it be made of pine, it should be stained and varnished, or ebonised.

Fig. 64 is a sectional view of the bass end of the sound-board or pan: *a*, vibrator; *b*, screws by which vibrators are fixed; *c*, mortice; *d*, sound-board; *e*, beech boxing round sound-board; *f*, pallet; *g*, pallet lever; *h*, pallet lever rail; *i*, spring rail; *j*, spring; *k*, wire crook; *l*, elastic band in lieu of steel spring; *m*, screw on which key rests; *n*, veneer; *o*, roll of cloth.

Fig. 65 illustrates a section of upper portion: *a*, bellows board; *b*, reservoir-board; *c*, wind-trunks, with valves at

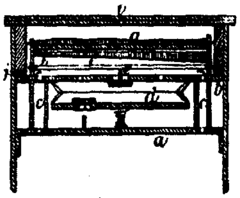

FIG. 65.

top; *d*, reservoir; *e*, expression valve; *f*, sound-board; *g*, pallet levers and rails; *h*, roll of cloth on edge of sound-board; *i*, folding side to case; *j*, wedges to secure reservoir-board. (T. Main, in 'Amateur Work.')

Musical Boxes.—These delicate instruments are very liable to get out of repair, either by direct violence or by neglect, a small defect sufficing to render them temporarily useless. Whilst it would be futile for any one ignorant of their construction to attempt remedying accidental defects, a small knowledge of the first principles of their mechanism will enable any ordinarily handy workman to repair all but very serious injuries.

Fig. 66 illustrates part of a cylinder, showing the progress of the 5 operations: *a*, pointing; *b*, boring; *c*, garnishing; *d*, gumming; *e*, turning.

The manufacture of a musical box may be divided into two very distinct parts. The first includes all that concerns the mechanical part of a box—

that is, wheels, pinions, barrel, spring, fly-wheel, etc., or the "clockwork" of the box. The second concerns more particularly the musical part of the box, viz. putting the desired tunes on the cylinder, tuning the key-board, finishing these two parts and putting them in their proper places, so as to have a playing box. About the first part, it is necessary to say nothing, everything concerning it having a great resemblance to watches, and especially to clocks. Clocks and watches being universally found, and everywhere easily repaired, the case will be the same with the mechanism of a musical box. As to the second part. For finishing an ordinary musical box, the following processes are necessary:—

First.—The tunes are pointed on the cylinder. (Previous to this, of course, the choice of tunes is made, with the notes necessary for playing them.) This pointing is effected by an instrument in which the cylinder is placed on its 2 points. A needle on a dial serves to make the cylinder turn, in accordance with the measures of the music (tune), whilst the pointers glide from one end on the cylinder to the other, making small dots on the cylinder in accordance with the notes of the tune.

Second.—At each one of these dots a hole must be bored, of the same size as the steel pegs. This is made by a very simple boring machine especially adapted for the purpose.

Third.—In each of these holes a steel-tempered peg must be placed, and all forced into the same height above the cylinder. The pegs are long enough to have a part in the inside of the cylinder.

Fourth.—The cylinder is partly filled with mastic gum, in order to fasten the steel pegs, and to give to the whole cylinder a certain consistency.

Fifth.—The cylinder is put on a lathe, and, with a file, is turned, so as to give to all the pegs a flat summit, and to make them all of a perfectly cylindrical surface.

Sixth.—The key-board must be turned in accordance with the note put on the cylinder.

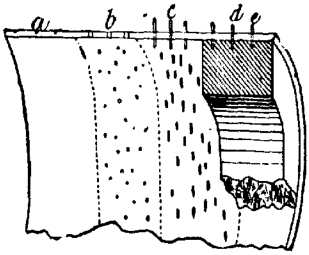

FIG. 66.

Seventh.—The key-board must be attached by screws to the plate of the musical box.

Eighth.—The ends of all the keys must be put in their right place, in respect to height (they must all be on a level), and with regard to the pegs of the cylinder.

Ninth.—The key-board in place, each peg of the cylinder must be bent forward, so as to pass directly by the middle of the point of the key corresponding, and more or less bent, so as to allow the key to produce its sound at the right instant; a special instrument with dial and hands is here again necessary.

Tenth.—Steel spirals must be put at the end of each key, and bent in the right shape, so as to stop the vibration of the key each time a peg comes to lift it.

In the preceding description, several operations have been intentionally omitted which are of no great consequence for a general comprehension. Before giving further details, it will be necessary to make three preliminary remarks. The first is a precautionary suggestion, that great care should be

taken never to take out any part of a box, except the key-board, without ascertaining whether the spring of the barrel is quite run down. It is easily understood that by lifting the keys of the key-board, if, for instance, the fly-wheel is removed, the spring being partly wound up, the cylinder, not being able to turn without the pegs attached to it, will revolve rapidly, and one of two things must happen, either the steel pegs of the cylinder will give way under the resistance of the key-board, and then break or be bent backwards, or, if the pegs be strong enough to resist, the key-board will be destroyed in pieces. Very often both cylinder and key-board may be broken in this way. Therefore, after having taken out the key-board, ascertain if the spring is at rest, and if not, let the box run down, and for more security, that no strain exists on the spring, lift the ratchet which hinders the spring from running backwards, and unwind it.

The second suggestion is: Before commencing to repair a box, observe at first if the pegs of the cylinder are all bent in the same direction, and if there be a few missing. If this be the case, there is all probability that the box need not be sent to the manufactory for repairs. But, if a certain number of pegs be wanting, or bent in all directions, especially backwards, no hope must be entertained of repairing the box, except at the manufactory itself, where all the particular tools are found necessary for making a musical box entire. In this way much expense may be avoided, and time and annoyance saved.

Thirdly, a very wrong impression is widely spread concerning the repairing of a musical box, which the writer will endeavour to correct. Very often a badly damaged key-board is alone sent to the manufacturer to be repaired or changed for a new one, or a new key-board is demanded to replace an old one, without sending back the whole box. In the actual state of manufacturing musical boxes, it is impossible to make a new key-board for a given cylinder, or the reverse—a new cylinder for a certain key-board—without having in hand the entire musical box. These two parts, which are the two most important of a box, are too closely connected to permit the mending of one without the other, or without the plate which carries them both. It is only when one or two keys are broken that it is possible to replace them without the entire box.

We have now given, in a brief way, an idea of the manner in which a musical box is made, and the indications when a box should be repaired at the manufacturer's, or elsewhere. We will now admit that the cylinder is in sufficiently good condition, and will mention, one after another, the accidents which may be easily repaired by any skilled workman, possessing ordinary tools.

Next to the cylinder, one of the most important parts of the musical box is the key-board. We will first see how all accidents happening to a key-board can be remedied.

It is well known that the number of vibrations of a pendulum in a given time, is regulated by the weight of the pendulum-ball. The heavier it is, the more slowly will it vibrate, and the lighter it is, the more quickly it will go. The same is to be found with the key of a key-board, which is nothing but the half of a tuning-fork.

The lower tones giving a less number of vibrations in a second than the higher ones, it will suffice to load the end of the key to lower the tone, and to lighten it to have a higher tone. It will also be easily understood that a thick key or a short one will vibrate more quickly than a thin or long one. After these suggestions, it will be very easy for any one to put any number of keys to the right tone.

Any person having had a key-board in hand, will have noticed that there are two kinds of keys; some having lead at the end, and others that have none. For those having lead, it will be sufficient to cut some of it to

elevate the tone, and to file the key between the lead and the brass plot, to lower it. For those without lead, the same must be done to lower the tone, but having no lead, must be filed near the end underneath, to elevate it. As you must avoid having any thin keys (these not possessing good sound), instead of filing a key to lower it, it will be often preferable to change the lead for a heavier one, or supply the deficiency by solder.

We have now to see in what manner a missing tooth may be replaced. Take a piece of steel and make a key of the same shape as the missing one, or the adjacent ones, but on the under part a heel must be devised, as indicated in Fig. 68. In the steel block of the key-board, with a file of the width of the key, make a notch as indicated by Fig. 67. Hammer the new key in its place, so that the heel will exactly fill the hollow space, and so that the key will be placed as much as possible in the right direction and right level. In making the new key, the point must be made a little longer and a little wider than the adjacent ones. Then temper the new key, draw it to a dark blue, so that it will vibrate like a good spring, and at the same time so that it can be filed. Whiten the heel of the key, put it in place, and solder it. This must be done with a soldering bit, which weighs at least 6–8 lb., so as to retain sufficient heat. Lay the copper pretty hot on the key when in its place, and after a few moments' delay the solder will run. The solder and acid are the same as used by tinmen. The key, well fixed, must then be finished, filed on the top to a level with the other keys, and tuned by filing it underneath. It is necessary here to say in what way the under part of a key can be easily filed. Put in the vice a small block of steel or brass, a little thicker than the key is wide, about $\frac{3}{4}$ in. long, with a small elevation, lengthwise. Place the key to be filed on this block, the whole comb being held in the hand under side up, and with a certain pressure the key will rise above the others, and

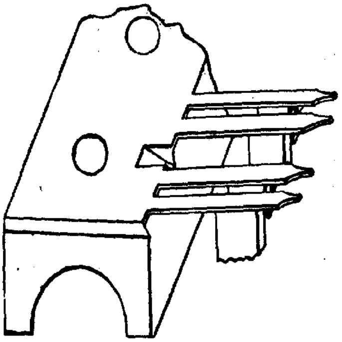

FIG. 67.

will be easily filed with a square file $\frac{1}{16}$ in. wide, and 6 in. long. When the key to be filed is in the middle of a long key-board, it will be advantageous to make an appropriate handle to the file, as indicated in Fig. 70.

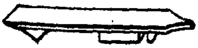

FIG. 68.

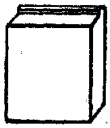

FIG. 69.

The point of the key must then be finished, that is, filed to its proper width (to correspond to the other

points), and, at the same time, brought as nearly as possible to the same distance from the two adjacent points. For putting the point to exact its

FIG 70.

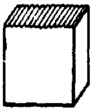

FIG. 71.

length, it would be well to hold the key-board with the keys perpendicularly on a piece of flat window-glass, and by reflection it will be easily seen when it is brought to the same length as the others.

Place the point of the key, when it is filed to the right width, as nearly as possible to its level, and proper distance from the adjacent ones. Sometimes it may be found necessary, however, to change the place of the point of a key; to lower it so as to put it on a level with the other ones, or to shift it to the right or left. In this case, a small anvil must be made, well tempered, of about the same shape as the one used for filing the keys, but quite flat on top, with no elevation. The hammer used must have one end tempered, with the end a little rounded and not too sharp. If a key is forged on the left angle, it will move to the right, and *vice versâ*. The key must be forged on the under side. Here a certain practice is quite necessary; the key must be well placed on the anvil, the spot to be re-forged resting well on it, and 2 or 3 strokes of the hammer will make the key move a little.

To lower or elevate a key, another anvil of the same size as the preceding one is necessary, tempered, but notched on the top (Fig. 71). The key is laid lengthwise and quite flat on this anvil, and by striking the key with the other end of the hammer (Fig. 72), which is flat and not tempered, the key will bend upwards. In both these cases much care must be taken, as it is very easy to break a key in using this hammer.

In case only a point of a key is broken, it is not necessary to replace the whole key. With the blowpipe, the end of the key must be untempered, but care must be taken that the flexible part of the key be not beaten and untempered (the sound would be lost); a small notch is made with a narrow file, and a small piece of spring is

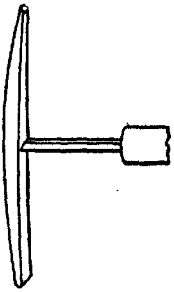

FIG. 72.

filed and pressed in. It will be easily soldered with a small soldering bit. Then the point must be finished as already indicated.

It may be well to remark here, that when a key is untempered and has no sound, it will sometimes regain sound by drawing it to a blue with the blowpipe, without previously tempering it.

Now the whole key-board being complete, no keys or points missing, it must be put on the musical box-plate, and the line of small dots, which every cylinder carries, will serve to indicate if all the points of the key board occupy their right places. This can also be seen by the pegs; when the cylinder turns, the pegs must all come exactly under the middle of each point

of the key-board. When it is ascertained that all the points are in their places, the key-board must be finished

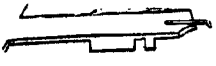

FIG. 73.

completely—that is, all missing spirals replaced, and the key-board then definitely tuned.

The tuning must always be done twice, because all operations upon a key change its tone a little, even when a spiral is changed; and before hammering a key, it must be brought to the proper thickness and about to its right tone. It may be advisable here to remark that in the first tuning it is well to leave the key half a tone too high, because putting a spiral at its end lowers the tone, and in general it is easier to lower the tone than to elevate it.

There remains now only to be seen what form must be given to the spirals, how to put the key-board in its right place, and, in general, how to have a good playing musical box.

The manner of repairing all defects in a musical box has now been indicated. The mechanical part now runs well, the key-board is repaired, tuned, and in good condition. Before indicating the form which must be given to the spirals of the key-board, and how to place the key-board itself in its right position, we offer the following suggestions.

The cylinder must be free to move easily up the 6, 8, or 10 tunes, as the case may be, and fall back readily to the first tune, being regulated by the spring at the left end of the cylinder. But care must principally be taken that the axis of the cylinder turns freely; on the other hand, it must have no play whatever to move lengthwise between the two bridges. If the least play exists, it will be utterly impossible to finish the box properly. The pegs of the cylinder must necessarily follow exactly under the points of the keys; if not, the box will never play well. If any play be found, it will easily be removed by bending the legs of one of the bridges of the axis.

This done, the spirals of the key-board must be bent their right shape, and the key-board put in its proper place. It will be well in a few words to describe the theory of the spiral,

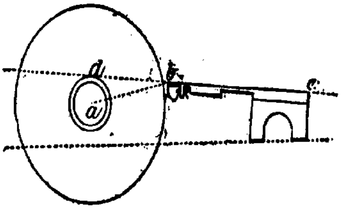

FIG. 74.

this being a very important part of the musical box. The manner in which these small steel stiflers are bent contributes very much toward making an excellent box. The upper side of the key-board must always make the same angle of the radius of the cylinder, passing through the point of the keys. This angle *a b c* Fig. 74, must be 165°, or, which is the same thing, angle *a b d* equal to 15°. It is not very easy to measure this angle, but in practice the following will amount to about the same results. Supposing the diameter of a cylinder to be $2\frac{1}{8}$ in., *a d* must be $\frac{1}{4}$ in. It will be observed that the upper level of the key-board, *b c*, prolonged, will attain pretty exactly the summing of the spring at the end of the cylinder. Supposing this to be the case, the spiral must have the shape indicated in Fig. 75 magnified. The end of the spiral must be as near the point of the key as possible without touching it. It must be observed that the

heavier a key is (or the lower the tone) the thicker must be the spiral, as it is more diffi ult to stop the vibrations of the key. As the cylinder turns, the peg will first touch the spiral at about the last third part (in Fig. 75 the peg is at the place where it should commence to touch the spiral), the spiral will fall back, and when the peg has reached the end of the key, the vibration of the key will have stopped. If the spiral is too thin, the peg will readily pinch it (it must then be changed), and will not sufficiently stop the vibrations; or if too thick, the spiral itself will produce a buzzing noise in stopping the vibrations of the key. To see if the spiral has a good shape and works properly, it will be best to let the box play slowly, the key-board in its place, and examine how the pegs act on the spirals, and see that they do not get out of place. Some practice will be necessary here to find out if the spirals must be bent forward (when they do not sufficiently stop the vibrations), or backward (when they make too much noise, or are pinched). For bending these spirals a pair of pliers (Fig. 76) with a hook at each end will be necessary. It must not be forgotten that the shape and strength of the spiral, its distance from the end of the key, its place backward or forward, all have an importance which must not be overlooked.

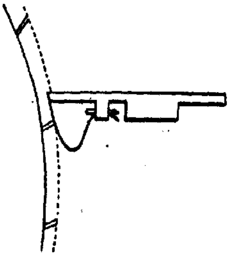

FIG. 75.

FIG. 76.

The only thing remaining now is to put the key-board in its proper place. 1st. As to height. The dotted line which is found on each cylinder will here serve as a guide; but it must be observed that, supposing the shortest key to be on a level with the dots, the longest ones must be a little below, about the distance of half a dot. This difference in level gives the difference in "rise" of the keys, the longer ones necessitating more rise than the shorter ones. If this level should not be right, the key-board must be left as it is, and one of the bridges must be raised or lowered accordingly.

2nd. The key-board must occupy the right place, as to left and right. That is, all the pegs must pass directly in the centre of the points of the keys. It will facilitate matters to observe if the points of the keys pass at the same distance between the pegs of the two adjacent tunes. Should they not, the cylinder or the key-board must be shifted right or left; the key-board by bending the feet in the opposite direction, the barrel by filing or elevating the metal piece which rests on the tune counter placed on the inside of the toothed wheel of the cylinder.

3rd. A good rise must be given to the keys of the key-board. If they rise too little, they will have but little sound; if too much, they will have a disagreeable sound, and, moreover, it will be difficult for the spirals to stop

the vibrations, or they will make a noise and get pinched. At the same time it must be carefully examined if the different keys produce their sound at the same moment; that is, in those parts of the tune when it is easy to observe that they should. This will be readily seen by letting the box play slowly. When the sounds are produced too late, the part of the key-board where this occurs must be put a little backwards, and if too soon it must be put a little forwards. This is obtained by bending the feet of the key-board in the opposite direction.

When the key-board is mended and tuned, it would be well to suggest that the spirals be bent only approximately, until after these last operations are completed, when the last touch must be given to the spirals, in order to obtain a musical box playing smoothly and agreeably.

After all this is done, it would be well to let the box play through all the tunes, and correct all the pegs that may have lost their right position, either right or left, by producing a disagreeable noise, by touching the ends of the keys when they should not, or by playing too soon or too late. When they play too soon the pegs must be bent backwards; when too late, forwards.

The case may happen that 3 or 4 tunes play quite well, and at the fifth one, for instance, all the pegs pass over the side of the ends of the keys. This will be corrected by touching that part of the counting wheel which gives the said tune.

Let us now resume, in a few words, the order in which all these different repairs are to be effected.

First, repair all concerning the mechanical part of the box, until, without the key-board, every wheel runs well. See that the axis of the cylinder has no play lengthwise, then that the cylinder moves freely on its axis. Repair all missing keys and points of the key-board, file the new keys half a tone too high, put all the points on a level and at the right distance from each other, place all the spirals, bend them appropriately, tune the keys definitely, put the key-board in its right place, finish the bending of the spirals to their proper shape, and then correct all pegs on the cylinder.

It often occurs when a musical box plays that the pleasure is destroyed by a continual buzzing noise, produced always by a piece of metal or wood not properly fastened. The best way to find out what part of the musical box produces this disturbing noise is to let the box stop, and make the keys resound from one end of the key-board to the other with a rounded point; the notes which cause this noise will soon be discovered, then continue with one hand to produce this sound, and at the same time with the other hand touch all possible parts of the box which seem to produce the noise, and as soon as, by touching, the noise ceases, the object has been discovered. Tightening the screw, or a drop of oil, will very often do away with the noise.

Wind Instruments.—We are indebted to Messrs. Hawkes and Son, of Denman Street, London, W., the famous musical instrument makers, for the following notes upon the care of wind instruments and drums.

A few hints on how to keep them in good order, and what to do when needing repair.

There are two kinds of wind instruments, viz.: wood and brass, the wood consisting of the following: piccolos, flutes, oboes, clarionets, and bassoons. The brass, of cornets, horns, baritones, trombones, euphoniums and bombardons.

Wood.—First we will take the wood: these instruments are very liable to crack or split unless great care is taken with them, especially in tropical climates. Immediately the player has finished with his instrument, it should be thoroughly wiped out with a clean soft rag or old silk pocket-handkerchief, till quite dry, thus preventing the moisture from penetrating the grain of the bore and splitting the

wood; one of the finest remedies is to pass an oily rag through the bore occasionally, say once a fortnight (salad or sweet oil being the best for this purpose); this will prevent cracking, and greatly improve the tone of the instrument. The mechanism or key-work should always be kept perfectly clean, and, as far as possible, free from dust, a spot of oil being occasionally put on the small steel blocks on which the springs work, and also between the metal pillars of the keys, thus giving that sharp, clean action to the keys and levers which is so essential in performing rapid passages. All wood instruments should be taken apart at the joints when not in use, otherwise the moisture will collect round the tenons, which will cause the wood to swell and crack the socket of the joint into which it fits. Some instruments are fitted with cork joints, and others with hemp or cotton lapping; in either case the joints should be slightly greased with a little fresh butter or vaseline (a specially prepared grease is sold for this purpose), when found to be dry or difficult to be put together. On no account should the joints or tenons be moistened with the mouth: this causes the cork to swell or the lapping to become uneven, which binds itself in the socket, and often makes it almost impossible to take the joints apart, ultimately involving the expense of an entirely new joint, sometimes a very costly item, especially in cases where the instrument has most complicated mechanism, a single joint costing from 3*l.* to 5*l.* or more.

Musicians are often handicapped by their instruments getting out of order when they are living in parts of the globe where there are no instrument makers or repairers, and where great loss of time would be involved in sending to a maker. Some of the minor repairs may be executed by the performer himself, if very great care is taken. The most common items being the breaking of springs and perishing of pads; both springs and pads can be obtained ready for immediate use from most musical instrument dealers throughout the world. There are two kinds of springs used on all wood instruments, viz. flat springs and round or needle springs; also two kinds of pads, viz. the white kid leather and the-skin pad, this latter being used for the more complicated instruments, such as oboes and the Boehm and 1867 system flutes and piccolos, the former being used for the old or simple system flutes and piccolos, clarionets and bassoons, etc.

To replace an old or defective pad, take off the key requiring repadding, select a new pad, seeing that it is the exact size required, then hold the cup of the key which contains the pad over the flame of a candle or small gas jet until it becomes fairly heated, the old pad can then be removed quite easily with a pin or needle; while the cup is still hot, a small quantity of shellac or sealing-wax should be rubbed in, and the new pad fixed immediately, pressing it well in, with the thumb upon the pad and the first finger at the back of the cup; great care should be taken to see that the pad is placed quite evenly in the cup, if not it will not perfectly cover the hole which it is intended for, and will therefore be quite as useless as the old pad.

The fixing or removing of springs is a rather more difficult operation than the above, the flat springs being sometimes riveted to the key, and sometimes fastened by a small screw, these being generally covered over by a small piece of cork, so as to save the key from making a clicking noise upon the instrument when being used. This cork should be scraped off with a small penknife and the screw taken out, when the old spring should fall off, the new spring should be selected of the exact size required, set in place, the small screw replaced again very firmly, and a thin layer of cork can then be put over this if required, by heating the end of the key and applying a little shellac or sealing-wax, as in the case of repadding. If the spring be riveted,

carefully file off the flat part of the rivet under the key and next to the spring and punch the rivet out with a small punch (new rivets for this purpose can be obtained from instrument makers or probably from an ironmonger). See that the new rivet fits the hole in the spring and key before fixing, then keeping the head of the rivet to the outside of the key, place the key downwards on a flat piece of iron or steel, and tap the inside point of the rivet with a small hammer until the springs become firmly fixed; a smooth file can then be used to finish it off neatly, and the cork covering can be replaced as mentioned above.

In the case of a split instrument, there is really no permanent remedy, beyond having the defective part replaced by new wood-work. Should the crack or split be of a slight nature, although sufficient to cause a leakage, a good plan is to rub some beeswax over the crack, then heating a piece of wire or long pin to pass it gently over the wax, which will cause it to melt and run into the aperture, making the joint air-tight, but this can only be said to be temporary. Instruments are often made in ebonite, which, being a composition, will not crack or split from climatic influences, but is of a very brittle nature, and if knocked or dropped will break in the same manner as glass or china. Instruments made of this material are strongly recommended for hot or damp climates, and are greatly used in India and Africa.

Brass Instruments.—These, like the wood, should have the greatest of care, and be kept perfectly clean, especially inside, as if neglected, the bore becomes corroded, putting the instrument out of tune, and rendering it hard to blow. A capital method for cleaning the interior, is to prepare some strong hot soda-water, pouring it down the bell end and turning the instrument round and round, so as to permit the preparation to flow into every slide and knuckle of the tubing; when this is done thoroughly wash it out with clean cold water, blowing into the mouthpiece and working the valves at the same time, so as to drain every drop of water from the slides and tubing, preventing a bubbling or rattling noise when playing. A little pure milk passed through the instrument after this process, puts a soft coating to the bore and improves the tone. The best material for cleaning the outside is powdered rottenstone and oil, but this is a very dirty process, and globe or metal polish is recommended for cleanliness and quickness. This only applies when the instrument is made of brass; should it be nickel or silver-plated, this method will quickly take off the plating and spoil the appearance at once. The finest method for plated instruments is the use of whiting and water applied with a soft rag; after allowing this to get quite dry, polish it off with another piece of clean soft rag, and a most brilliant appearance is obtained.

The greatest trouble generally experienced with brass instruments, is the valves or pistons not working freely; should a piston become sluggish or work badly, unscrew the top and bottom caps of the valves, take out the piston and thoroughly clean it in hot soda-water, take a cleaner or small stick with a piece of clean rag wrapped round it, sufficiently large enough to pass easily through the outside casing of the valve, and work it backwards and forwards until every particle of grease and dirt is removed, then dip the piston into clean cold water, and place it back again into the instrument. On no account should grease or oil be put into the valves, as this is, in many cases, the sole cause of the trouble. Should the springs which work the pistons become weak, they can sometimes be strengthened by taking them out and pulling them a little outwards, i.e. making them a little longer; if this has not the desired effect, a new spring must be obtained.

The slides are also a source of trouble if not properly looked after: they become fixed and it is then impossible

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to tune the instrument or clean it. In such cases a little oil should be put round the edge of the tubing and the instrument heated over a flame for a few seconds to enable the oil to run between the outer and inner tubes; this will often release the slide, and when it has been extracted, it should be well cleaned and a very small portion of grease put on the inside tubes before being put back into the instrument. The same treatment may be adopted when mouthpieces or shanks become fixed, these may also be lightly tapped with a small hammer at the joint where they are fixed, which will also help to loosen them.

One of the greatest difficulties with brass instruments is to keep them from getting dented or bruised, a very bad dent often putting an instrument out of tune, as well as making it harder to blow. This is a repair which can scarcely be accomplished by a performer, as it often necessitates an instrument being taken to pieces and the defective part being put right and into shape again by the use of specially made tools which are only to be found in instrument factories, in such cases there is no alternative but to send them to an instrument maker or repairer.

Drums.—In the handling of drums, no matter whether side, tenor, bass drum or tympani, the greatest care should be exercised in tightening the heads. Many drums are spoiled and the tone ruined by wrongly tightening or bracing up the braces or screws, whichever the case may be, they should be tightened in opposite directions, until all are pulled up to the same tension, thus keeping the head quite even or level upon the edge of the shell. The fitting or lapping of new heads is another most important matter; when a new head is required, allowance must be made for the lapping round the hoop, which holds the head in position (this hoop is termed the flesh hoop), about 4 in. being allowed for a side drum and 6 in. for a bass drum. The most perfect method for lapping a head is as follows: lay the bass drum flat on a table, and take off 4 braces, then loosen the cord all round sufficiently to slip the steel out of the hoops. Follow the same proceedings exactly for side drums.

The time necessary for soaking heads in cold water varies according to the thickness of the skin: for bass drum heads from 5 to 15 minutes. When taken from the water, the head should be hung on a rail or rope line for about 15 minutes, and then laid on a flat table with the smooth side downwards. Place the flesh hoop on the skin so that the part for lapping is equal all round, then lap 4 equal corners first, then 4 equal corners again between the other 4 corners already lapped, making the head lapped in 8 equal places round the flesh hoop. The above system of lapping heads enables drummers to lap them in a true circle, and is most important. To make sure the head is lapped in circle, the drummer should measure across the diameter each way, so that if it is not, he can unlap or tighten parts where not in circle. Lapping a head out of the true circle will ruin the best drum made.

A more simple method is to strike a true circle on a deal top table to fully the outside measurement. This can easily be done by the use of a piece of string with a loop at each end, using a wire nail for the centre and a blue lead pencil for the circle line. Immediately after lapping the head on the flesh hoop, it should be put on drum and lapped down all round with the flat side of a mallet or pulled down with the hands. The cord should be gradually pulled up tight all round, so that the head is pulled down an equal distance. The head of a bass drum should be pulled down fully ¾ in. equally all round while it is wet; side drum heads fully ½ in. all round.

The pulling down of heads when wet equally all round drum can be easily regulated by the braces; then the drum should be laid flat on its side with new head uppermost in a

perfectly dry place (exposed to the air if possible) for 48 hours before it is fit to be played on; it will then require bracing up tight before it is ready for use.

Artificial heat for drying the heads will ruin the durability and tone of the skin.

The beating head for bass or side drums should be slightly stouter than the other one; this applies particularly to side drums, where it is necessary to get a sharp repeat from the snare gut. For lapping, it is best to have a special lapping tool, but if this is not available, the drummer can use the handle of a strong table spoon. Drum heads must not be folded, but rolled while the skin is dry. If the head is folded sharply to cause a crease or long white mark, it is almost certain to break in wear from such marks.

NETTING.

(*See also* TYING AND SPLICING.)

Tools.—(1) The tools employed in netting are exceedingly simple, and can, in case of necessity, be made by any person with the aid of an ordinary pocket-knife and some pieces of hard wood. The most important are the needles on which the string to be employed is wound, and the mesh pegs or spools on which the netting is worked.

Needles are of two kinds: those made alike at both ends, with converging prongs, between which the twine is passed (*a* Fig. 77), and those made with an eye and tongue at one end and an open fork at the other (*b c d*). On these the twine is wound by fastening it to the tongue, then carrying it down one side to the prongs of the fork and bringing up the other; then hitching it over the tongue and carrying it down to the fork again, on the same side as that it was brought up, and so repeating the operation until the needle has sufficient twine wound upon it. The needles made with eyes will be found superior to those alike at both ends, as they are not liable to be caught in the net whilst working. They are made of various sizes, according to the stoutness of the cord they have to carry, and are modified, so as to fit them for various uses. Sometimes the eye and tongue are made very long, as in *b*, which is a reduced representation of a needle used by the Hull netters, its advantage being that it carries a large amount of twine, the hitches of which pass round the sides of the long tongue without making a sudden swelling, which is very inconvenient to the netter, as it prevents the needle being passed rapidly through the meshes.

In case needles of the ordinary kind cannot be readily obtained, substitutes may be extemporised out of two pieces of wire bent as in *e*, the wires being

soldered, or, in case of necessity, even tied tightly together.

Short needles, about 4 in. long, are point, and carrying the string sunk in the broad grooves on the sides, it passes through the meshes with great

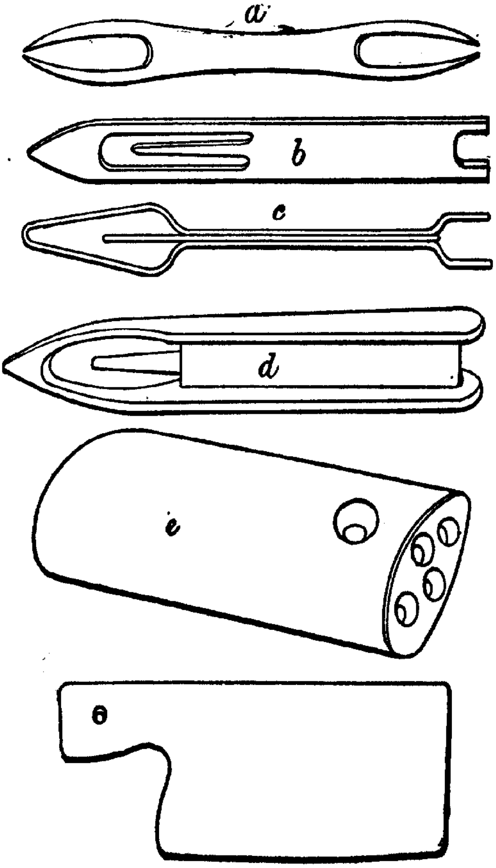


FIG. 77.

required in mending nets. That represented in *d* is an exceedingly convenient form; being thinner at the facility, a point of much importance in mending damaged nets. Netting needles can be purchased of any re-

quired size at most cordage warehouses, and they are readily made from thin pieces of hard wood, such as box, oak, ash, etc., by the aid of a common fret saw and a half-round file.

Mesh pegs or spools, on which the netting is worked, are best made of very hard wood, such as box for the smaller, and oak or beech, etc., for those of larger size. A considerable number are required if various nets are being made, as the size of the openings in, or meshes of, the net depends entirely on the size of the mesh peg employed. Cylindrical or round mesh pegs, which are sometimes used, are much less convenient than such as are flat. The edges of flat spools should be quite straight; otherwise the meshes of the net will be of unequal size; and they should be very smooth, so that the loops will slip off rapidly when desired.

Mesh pegs of the form shown in *e* are used by the Grimsby netters for the sea fisheries. They are all 4 in. long, and usually made in sets of 5, the number being shown by the shallow holes at one end of each peg. No. 1 is 2⅛ in. wide by 1 in. thick; No. 2, 1⅞ in. by ⅞ in.; No. 3, 1⅝ in. by ⅞ in.; No. 4 (shown in the figure), 1⅜ in. by ⅞ in.; No. 5, 1⅛ in. by ⅝ in. They have each a hole bored through the short diameter for the purpose of stringing them together.

When large meshes are required, as in walling for trammel-nets, the mesh peg would be too broad to be held by the thumb and forefinger, in which case it should be made as in *f*, the hollow part passing between the thumb and bottom joint of the forefinger of the left hand. These mesh pegs can be made of any desired width; but when very wide they should be made very short, never exceeding a few inches long.

It is a very common error to call mesh pegs or spools by the name of meshes, and a great amount of confusion results from using one word to signify two things. By the Yarmouth netters a mesh peg is sometimes termed a "shale," and by some writers it is spoken of as a mesh pin, or mesh stick.

Meshes.—Meshes are the openings between the cords of the net. They are either diamond or square shaped; each mesh, except those at the sides of the net, has four sides and four knots, one at each corner. The meshes are formed by netting a succession of loops. The last row netted consists of loops, each of which, with the halves of two loops in the previous row constitutes a complete mesh. Thus in A Fig. 78, *a b c* are the last loops formed, *d* is one being made (the needle and mesh peg are not shown for the sake of clearness), *e* is a loop in the row previously made, which would form part of the next mesh to be made if the netting were continued.

The string or cord on which the netting is commenced is usually termed the foundation. It is shown in *f*.

Knots.—The knot employed in making nets is that which is known as the "weaver's knot" or the "bend knot"; it is used not only to join together the ends of the cords of which nets are made, but is the means by which the loops forming the meshes are fastened together, every knot in a net being a weavers' or bend knot. As the mode of making this knot with rapidity is not very generally understood, and as the knowledge of its arrangement is of essential importance to the netter, it is necessary to explain its formation at some length. The simplest mode of making a bend knot is as follows: Bend a piece of twine into a loop *c d* Fig. 78 B; pass the second piece of cord through the loop from the farther side; then carry it round behind the two cords of the loop, bring it forward and pass the end under itself, bringing it out at *a*; pull the end *b* tight, and the bend knot is completed. When one of the ends of twine is very short (as is usually the case in net mending) it can be made into a loop, *c d*, and another piece of twine can be securely tied to it, even if the loop is only 1 in. long. On looking at the knot, it will be seen

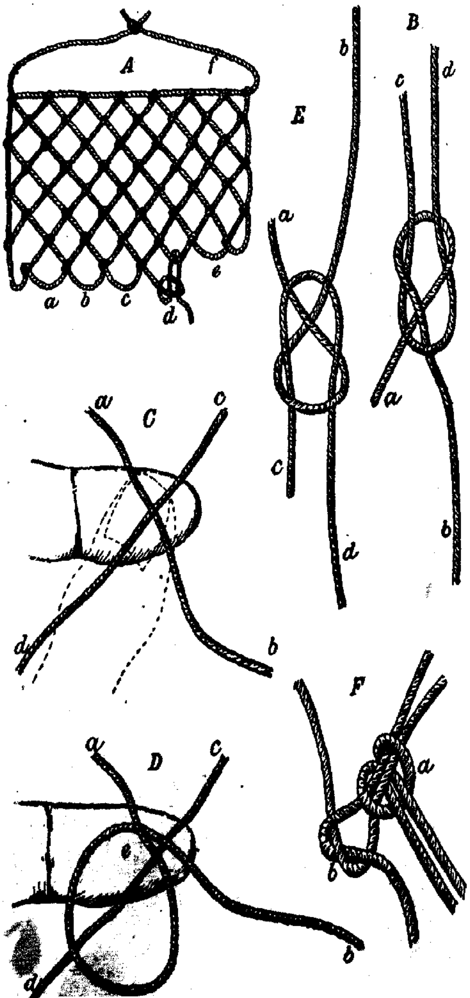


FIG. [illegible].

that it can be securely tightened by pulling the end *b*, which bites the end *a* securely; whereas if *a* is pulled, it slips under *b* without biting.

The above explanation shows the formation of the knot as it is used when stout cords or ropes are united by its means; but when it is employed to join threads or string, as in weaving or netting, a much more expeditious mode of making the knot is employed. The ends of the two cords to be united are crossed on the end of the forefinger of the left hand, the cord *a b* Fig. 78 C, being first placed on the finger, and the other cord *c d* put across it. The left thumb the position of which is shown by the dotted line, is then placed over the crossed cords. The cord *b* is then to be wound round (over the thumb) in a circle and passed between the two ends, behind *a* and before *c*, as shown in Fig. 78 D. The knot is completed by turning the end *c* downwards, passing it through the loop at *e*, securing it under the left thumb and pulling *b*, when the knot is formed as shown in Fig. 78 E. It is also represented in Fig. 78 B, but turned over to show the other side, the letters of reference being the same in both figures. Facility in making this knot *must* be acquired, as its use is indispensable to the netter.

A knot which will be found of great use in shortening or lengthening the cords employed in stretching out the different parts of a net whilst it is being mended is shown in Fig. 78 F. A loop of cord *a* is formed into an eye; through this the two ends of the same, or of a second, cord are passed and twisted, as shown at *b*; this secures the ends, and prevents them slipping back through the eye. The great advantage of this knot is that when it is wished to shorten the cord, the eye is pushed farther back, and the twist or half-bend pulled tight down to it. On the other hand, when it is requisite to lengthen the cord, the reverse proceeding is had recourse to.

It is not generally known that there are two perfectly distinct modes of netting; one of these, which is adapted for making small meshes, is the only one usually recognised; the other is employed for strong work and coarse meshes. The former is called the under edge, or little finger knot, or, in general parlance, simply "netting."

Making a Net.—To commence a net, tie together the two ends of the cord forming the foundation (*f* Fig. 79 G), and secure it firmly in any convenient manner, as by passing it under the foot, letting the part to which the netting is to be attached reach 3-4 in. above the knee when the netter is seated. In making large nets, which are most rapidly executed if the netter works standing, the foundation should be fastened to a hook, or rod in a wall, placed as high as the face of the netter; it then not only bears the weight of the net, but also supports the left hand, which holds the mesh peg. Tie the loose end of the string with which the net is to be made, which has been previously wound on the needle, to the foundation, as shown at *d*. The mesh peg *s* is held between the thumb and forefinger of the left hand, and the knot *d* is pulled up close to its edge. The needle carrying the string is brought back over the mesh peg, then forwards underneath it, the string being caught by the third finger *r*, which should be kept well away from the mesh peg as as shown in the figure; it is then carried forwards under the mesh peg and then to the left, being caught by the thumb as shown at *t*. The loose string is then thrown forward on the foundation, and the needle, having been brought backwards, is again passed forwards through the loop of cord that is hitched on the third finger, then under the mesh peg, and lastly through the foundation; this is the position represented in Fig. 79 G. The right hand is now shifted from the back part of the needle to the front end, and it is pulled forwards from under the mesh peg and through the foundation. By this action the loose cord is drawn tight round the little finger, and the

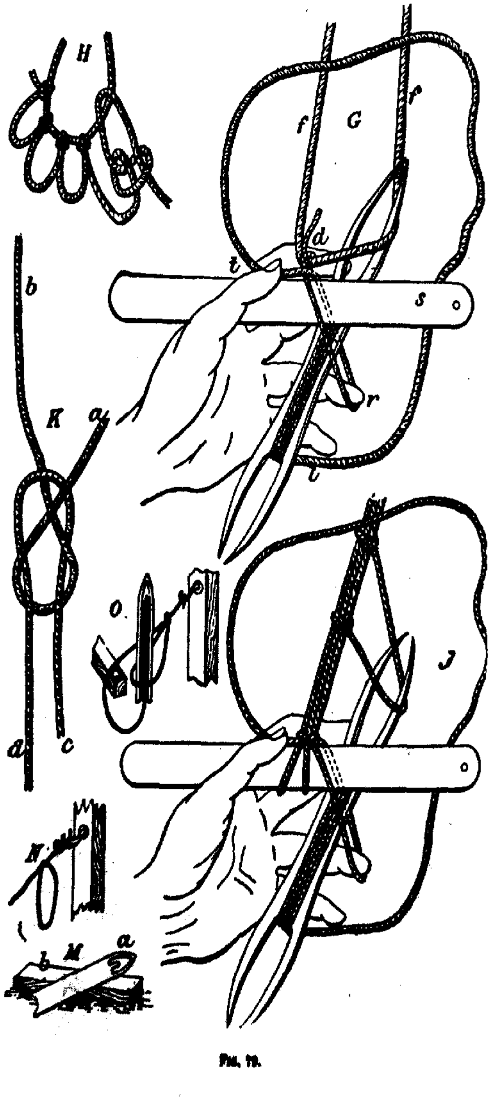


FIG. 79.

knot is completed, but requires tightening. This is done by first loosening the cord under the thumb, then allowing it to slip off the third finger; all the slack cord is then pulled up by the right hand, and when the knot which is thus formed is pulled close to the mesh peg (against which it is held by the forefinger), the loop is allowed to slip off the little finger at *l*, and the string is pulled tight, thus completing the knot and netting a single loop on to the foundation. In describing these movements it is necessary to mention them as if they were perfectly distinct from one another, but in the actual practice of an expert netter there is no pause between them, and they follow each other so rapidly as to seem one continued movement.

In Fig. 79 G, the thumb and forefinger are shown away from the knot in order that it may be seen, but quick workers hold the end of the thumb and tip of the forefinger together, and the second finger holds the knot as it is tightened.

The loop first netted is allowed to remain on the mesh peg, and a second, which is a repetition of the first, is then made, and as many more as may be required to complete the first row. When these loops are too numerous to be conveniently held, they are pushed off the left end of the mesh peg. The loops in the first row netted do not form complete meshes, but when the mesh peg is withdrawn appear as in Fig. 79 H, which shows a foundation with three loops netted on it and a fourth not tightened up. If the foundation is pulled out before a second row of loops is netted, the knots become loose, and the string lengthens into a straight cord.

When the required number of loops has been made, the mesh peg is pulled out and the foundation and the row of loops are turned over, so as to bring the under side on top and the right hand end to the left. The netting is then recommenced in the same manner, with this difference, that, instead of passing the needle through the foundation, it is passed through the loops of the row first made; these being taken up in succession one after another. The mode in which a loop is taken up is shown in Fig. 79 J, where two loops of a row are shown on the mesh peg and a third in the process of formation (to avoid confusion, the other parts of the net are not shown).

Netting on to a row of loops is done with much greater facility than netting on a foundation cord, and should be practised by the learner in the first instance, if he can obtain a teacher to net a few rows for him to begin upon; the first loop on a foundation is more troublesome than those following, as the foundation cord is not kept close up to the mesh peg.

In looking at the loops made in netting, it will be found that they are united by weavers' or bend knots, as shown in Fig. 79 K, the bend being formed by the loop that is taken up, and the cord *b* being that attached to the needle. It follows that if *b* is pulled tight, it bites securely upon *a*, and renders the knot firm and difficult to unpick.

Every described a different method of holding the mesh peg, which he terms the spool, by which he claimed to gain a considerable increase in speed. He says there is nothing which tends so much to swiftness in netting as a proper and loose or easy way of holding the mesh peg; this will be best understood by an examination of Fig. 80 L, which gives the true position of the fingers at the commencement of the stitch.

Reid says that Every's method is a well-known mode of holding the peg, and one which comes quite naturally to learners, but in the first lessons to his workers it is especially avoided, as it is considered the very worst form of holding the mesh peg. The importance of this to a worker is very great, as, should the habit be contracted, the value of the work would be diminished 50 per cent., both in speed and quality of work, and any worker would be

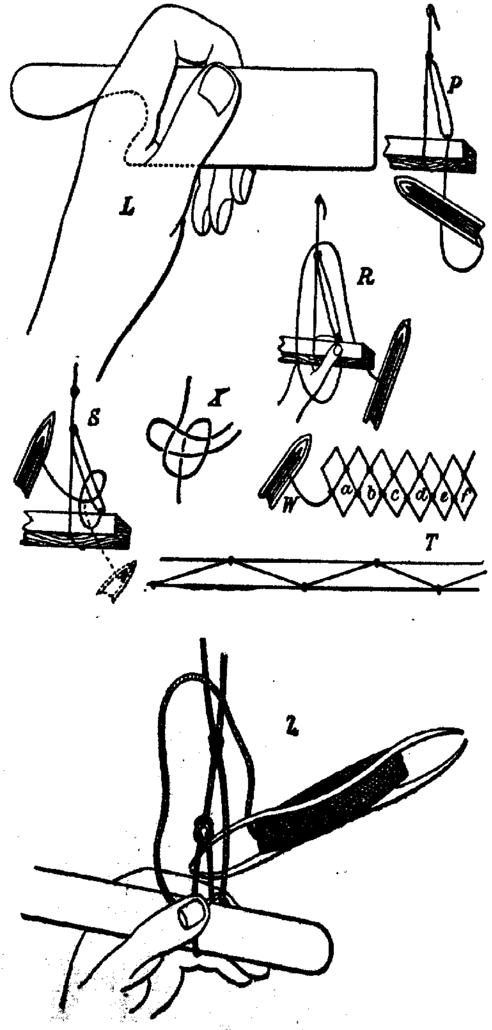


FIG. [illegible].

discharged if found using her tools in this manner.

In a correspondence which took place in the 'Field' some years since, F. Allies stated that, with an inch spool and patent thread, a quick netter ought to more than double the rate of speed claimed by Every, and net at the rate of 3600 loops per hour. (T.)

(2) The instruments for netting consists of a needle *a*, and a mesh *b* (Fig. 79 M). From 8 in. to 10 in. is a good length for the needle, while the mesh stick must vary according to size of net. A mesh stick will make a mesh twice its own size. Thus, a stick ½ in. square will make a 1 in. mesh. To fill the needle, pass the string around the tine, or inside point, round the heel of the needle, then up round the tine again, until the needle is full. Fasten the end of the string to a hook and tie a loop in it N. Lay the mesh stick underneath the string, and pass the needle up through the loop O (Fig. 79). Pull it tight, so that the end of the loop rests against the mesh stick P (Fig. 80). Now comes the important part—the formation of the knot. Hold the mesh stick in your left hand with the thumb on the string, and with the needle in the right hand; now with a quick jerk throw the bight or loop of the string over the stick and left wrist, as shown in R. Push the point of the needle up between the first loop made and the string to the left of it, pull the needle through, and bring the knot into shape S, then tighten by pulling the needle in the direction of the dotted lines, and the knot is tied. This simple knot is the foundation of all net-making, and once succeed in that and you will very soon be able to manufacture almost anything. Slip out the mesh stick and take the same stick through the loop you have just made, and so continue on, passing the needle every time through the last loop made, until you have made enough. By the time you have made as many as you think requisite, your work ought to look something like T. Unfasten the end from the nail and untie the first loop made. Pass a piece of cord through the upper row of meshes, tie the ends of the cord together, and hang it over the hook. Go on with the work as before, only do not slip the loop off the stick as at first. Knot through *f* Fig. 80 W, then through *e*, *d*, *c*, and so on, until you have travelled along the whole width. Then turn the work over and travel back again in the same manner. Presuming the string breaks, or you wish to join another ball, the way to do it is with a "becket-hitch," commonly called a "weaver's knot." Form a bight, pass one part up through it, then over, under and back through its own loop, as in X.

Lawn Tennis Nets.—There are many persons who are thoroughly familiar with the ordinary method of netting—that is to say, as far as making the loops and meshes is concerned—who do not know the construction of square-meshed nets, such as are required for lawn tennis and other similar games. The following instructions will enable anyone capable of making the ordinary diamond-shaped netting to construct also square-meshed nets for tennis or other purposes.

In making nets in which the meshes are of large size, the spools or mesh pegs are usually flat. When very large they become awkward to hold, in which case it will be found much more convenient to have them cut the shape shown in Fig. 77 *f* than to allow them to remain of equal size from end to end. In using these spools, the base of the thumb goes into the deep notch shown at the left extremity of figure.

By the term loop, we mean the loop formed around the spool, as each knot is made in succession, the last row netted always consisting of a series of loops, each of which, with the two loops of the preceding row into which it is knotted, constituting a complete mesh.

In making square-meshed netting it is necessary to be able to make the knots in a different manner from that usually adopted, to net in fact with

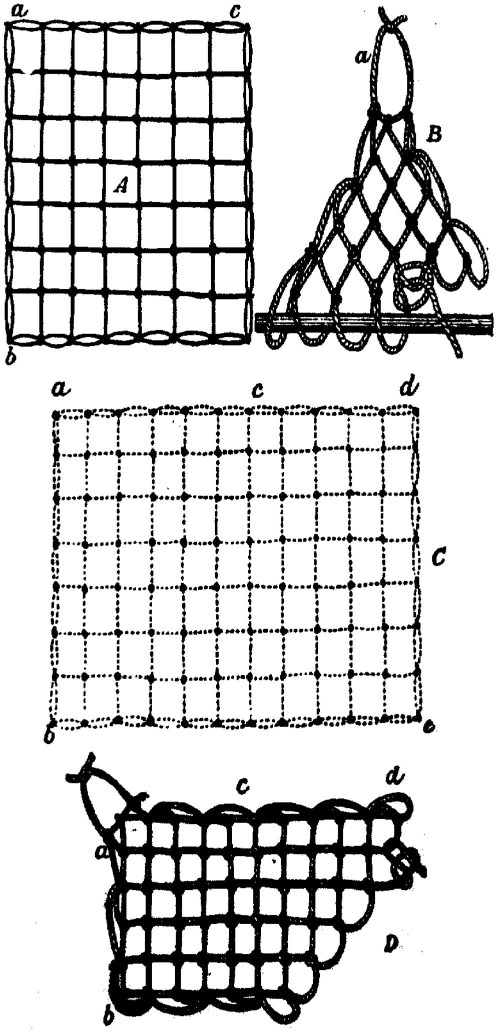


FIG. 81.

the fishermen's knot. This is done as follows: Let the spool and netting be held in the usual manner. Then, to make a new loop, bring the needle backward over the spool; then carry it forward under the spool, *but without catching the string on any finger*. Pass the needle upwards through the loop that is to be taken up, and pull it close up to the spool, seizing the twine passing through the loop with the forefinger and thumb of the left hand. The loose twine should be allowed to fall over to the left, and down in front over the netting; and the needle should then be passed upward between the loop that is being taken up and the last one secured. On tightening the loose twine, the knot is completed.

This mode of netting is shown in Fig. 80 Z, where the twine may be traced from the last-formed knot round the spool, through the loop, then to the left, where it is secured by the thumb; the loose twine is shown lying over the netting, and the point of the needle is just inserted behind the loop that is being taken up. To finish the knot, the needle must be pulled through, and the string drawn tight.

A very slight examination will show that the knot made by this method is the same as that resulting from the common mode of proceeding.

In reality the stitch is much more simple than the one ordinarily used, and can be made with very much greater rapidity. It necessarily follows that anyone used to the old mode will find this new plan awkward at first, and will fail to net as neatly as before; but the strangeness is soon overcome, and great rapidity attained. With stout cord the advantage is very great; there is no sawing of the twine required to tighten the knot, consequently no fraying either of the twine or the fingers.

Another immense advantage possessed by this knot is that it can be made, using one, two, or three fingers instead of the spool, and with a short end of the string without a needle, so that in mending nets it is really invaluable.

Two points, however, we have omitted to mention: the method is not adapted to very small netting, and it is always necessary that the spool should be larger than the needle, otherwise the latter sticks in passing between the loops. Again, there are certain stitches that cannot be made in this manner, such as the first row or foundation of a diamond-meshed net.

Diamond-meshed nets are commenced, as is well known, by netting a number of loops into a foundation, and when as many as are required are made, netting a second row into the first.

Square-Meshed Nets.—Square-meshed nets, as shown at Fig. 81 A, are made by commencing at one angle or corner, and netting diagonally across the square to the opposite corner. In beginning a square-meshed net, one loop *a* Fig. 81 B, is first netted on to the cord which is used as a foundation; this loop may be of larger size, as it is only temporary, being removed when the net is complete. The spool is then withdrawn, and two loops are netted into the one first made; the last of these two should always be made with what is known as the fishermen's knot, as, if made in the ordinary manner, a lopsided knot is the result. The spool is again withdrawn from these two, and a new row is commenced; this will consist of three loops, two being formed by taking up the last loop of the previous row twice. The netting is to be continued in the same manner, the last loop of every row being taken up twice. By this means a half-square of netting will be formed, of which the last row is the diagonal, and the two sides *a c* and *a b*, Fig. 81 A, form the selvedges on each side of the half-square. When the sides of the square are of the required length, a single row should be netted without the extra loop at the end; and then, to form the remaining half of the square, the rows should be con-

tinued, but with this difference, that, instead of netting two loops into one, as before, *the last two loops in every row should be taken up with the needle together*: thus the width of the netting will be gradually diminished to one mesh, and when the net is stretched out it will be found a complete square formed of square meshes, as shown at Fig. 81 A.

In order to make the angle neater, the spool should be withdrawn before the last knot is tightened, so that the last loop is made to come into the angle; and the first knot should be untied, and the large front loop *a* Fig. 81 B also drawn up tight, so as to render the net correct in shape.

Oblong Nets.—The netting of an oblong net, such as shown in Fig. 81 C, is a rather more complicated matter. This is commenced with a half-square as before, the length of the sides determining the width of the net. This done, at the end of the next row the last two loops are to be taken up at once; but on returning to the end of the succeeding row, two loops are to be netted into one as before, and this alternation is to be continued. At the end of *one row two loops are to be taken up at once*, and at the end of *the next row two loops are to be netted into one*. The side at which the latter is done—*a c d*—will be the long side of the oblong, and when this is of the required length, two loops are taken up at *each end of each row*; and the net diminished to the point *e*.

In making an oblong great care must be taken always to diminish or increase at the proper sides of the net, otherwise a confused mass of useless netting will be the result. This error is easily avoided, if a few threads of coloured string or a riband be tied at the angle *b*, to show which side should be diminished by taking up two loops in one.

This proceeding may perhaps be rendered clearer by a consideration of Fig. 81 D, in which *a* is the first loop. Five rows are then netted, each being increased by netting two loops into the last of each row, making the half-square *a b* and *c*. Then on returning to *b*, two loops are taken up together, and at the side *a c d* two loops are netted into one, and when the required length *a* to *d* is reached, two loops are taken up together at the end of every row and the net diminishes to a point completing the oblong.

A lawn tennis net of the regulation size is 3 ft. 6 in. high by 42 ft. long, and the mesh is 1¼ in. square. The strongest and most durable cord to employ is that called mattress twine, the usual price being about 6*d.* a ball; 10 balls are generally required for an ordinary-sized net.

To make a net of this size a half-square of 40 rows would have to be made before one side should be diminished by taking up two loops in one, and then the long side *a c d* should be continued for 192 rows before diminishing to the corner *e* Fig. 81 C by taking up two in one at both ends of every row.

It is hardly necessary to add that a net of 10 or 12 yd. length for double games can be made by simply continuing the side *a c d* until the required length is obtained.

Mending Nets.—The ability to mend nets is an art of rather rare occurrence; except amongst fishermen and their wives, there are perhaps 100 persons who can make nets for every one who can repair them when damaged. The first step towards acquiring this power consists in learning to make a bend knot. This has been already described and illustrated. A knot, which will be found of the greatest use, not only in fastening the cord to which the foundation of a net is attached, but also in stretching out the different parts of a net whilst it is being mended, has been illustrated in Fig. 78 B.

It is impossible to mend nets by using the ordinary netting stitch which is employed by most persons. What is termed the fisherman's mode of making the knot is absolutely necessary. This was described fully on

p. 221. In mending a torn or damaged net, the first operation is to spread the net out as flatly as possible, *with the loops in the same position with regard to the mender as they were to the netter when the net was made.* In the case of a lawn-tennis net the corner or angle at which the net was commenced must be farthest from the operator. The damaged or torn part must then be cut away in regular rows, as shown in Fig. 82 E, where the whole of that part represented by dotted lines is supposed to have been removed. The short ends of string that are knotted into the loops 2, 3, 4, 5, and 6 must be unpicked, when those loops will remain uninjured; and the knots at 14, 15, 16, 17, and 18 must also be unpicked, so as to liberate the loose ends of those loops that have been cut away; but the knots at the sides of the part removed, viz. at 1, 13, 7, and 19, must be left, otherwise those loops would be opened, which is not requisite.

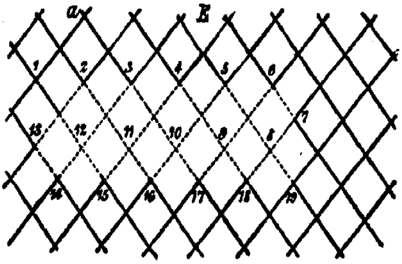


FIG. 82.

The mender should then take a short needle (one of those alike at both ends is most convenient for mending); fill it, but not over-full, with twine of the same size as that used for the original netting; or twine slightly finer may be employed, as, being new, it will be stronger than the old. The end of the twine should then be fastened by a bend knot to the loop 1, the needle passed upwards through loop 2, then the twine should be taken between the thumb and forefinger of the right hand, and a length measured equal to the distance from the knot at 1 to just beyond the knot at *a*, this gives the exact length of twine required to form the new loop from 1 to 2; this new loop is caught on the little finger of the left hand, and pulled back; the point of the old loop 2 and the cord passing through it are held by the thumb and forefinger of the left hand, the loose twine is thrown over to the left, the needle is brought to the right, and the knot is completed by passing the needle under the loop 2 from right to left. In short, the loop 2 is taken up by the fishermen's knot, only made on the little finger, instead of on a spool, the length of the twine required to form the new loop being ascertained by measuring from 1 to *a*.

When there are a large number of meshes to be filled in, a spool may be used, but when there are only a few, it is neither necessary nor desirable to employ one.

The new loops from 2 to 3, 3 to 4, 4 to 5, and 5 to 6 are made in the same way, and then the side 6 to 7 must be made by netting into 7 as into a loop. This completes the first row of new loops.

The second row has now to be netted into the first. If performed as recommended, without a spool, it may

be worked backwards from right to left with great facility; or the netting may be turned over on to the other side, when the second row can be completed in the usual direction, from left to right.

In this manner the space cut away must be filled up, until the last row is reached; this requires different treatment. In Fig. 82, 3 rows of loops only are shown as having been removed. When the second has been entirely replaced, the twine will be attached to the knot at 13; to complete the repair pass the needle through the loop 14, and secure it by a bend knot, 14 being the loop of the bend knot, and taking care that the side 13 to 14 is of the proper length; then knit into loop 12 from 14, return to 15, and so on, connecting the whole in the following order—11 to 16, 10 to 17, 9 to 18, and lastly 8 to 19, which completes the repair. Of course the reparation of larger rents and more extensive damages is only an extension of the same proceeding as is here described with reference to three rows of loops. The description of this process doubtless appears tedious, but the performance is, with a little practice, sufficiently easy. (T.)

Making a Round or Bag Net. To net a round net a loop is first made to net the first meshes upon. This loop can afterwards be drawn up tight (assuming the net may not have a hole in the bottom of it), or it may be cut away in which case the cut ends can be pulled out through the inner bights of the second row (now the first inner row), then drawn together and bound with string or worked into a grummet. In making a bag net, about six meshes are sufficient for the first row, making the first small at the tapered end of the mesh, the last two being worked loosely at the broad end. It will then be found that the first stitch of the second row will be fairly regular in size, while in the third all will come even. Of course, if commencing with six meshes, other stitches must be added with succeeding rows. This is done by working two meshes on each loop of the previous row, or two on each alternate loop, according to the shape intended.

Rabbit Nets.—The purse rabbit net is square-worked on a 2 in. mesh stick, and as a rule there are 10 to 12 rows of the same number of stitches. Fine string is commonly used, but flax sewing twine, such as is made up in skeins, is suitable. The draw line can be carried through all the meshes round the neck of the net, having a metal ring by which it can be pegged over the burrow. Or 4 rings can be put at even spaces on the net and the string run through these, but in this case the string is pegged over the burrow and not the rings.

Preserving Nets.—(1) It is very important that fishing nets should not be allowed to remain heaped up while they are wet, for if left so they will perish. They should be hung over lines or else turned over and the air let in the mass each day.

(2) To preserve sea fishing nets (or sails) take 2 lb. salt, 2 lb. alum, 1 lb. chrome alum, and scald in 4 gal. of water. When the liquor is cold steep the nets in it for 24 hours, lifting or turning them three or four times. This liquor can be used for another lot if it is brought up to strength by adding half the quantity of the chemicals. To tan nets or sails take a good-sized iron pot such as will take the net and to the water in this add 4 lb. cutch or bark, and boil hard for two hours. If a new net, let it be in this preparation (when cold) for two days. Take it out and hang up to drip and dry *in the sun* for one day. The sun is necessary to fix the tannic acid. After the net has been used about two weeks, dip it in the bark again, but only for about a minute, then dry in the sun again. Fishing lines even when new need not be left in the bark solution more than a few minutes, then dried in the sun. Cutch or catechu, it may be explained, is a solution of tannic acid which vegetable

fibre will absorb and hold well, but cotton and what is termed cellulose fibres do not take it so well and they have to be re-done at periods according to the use they have. Cutch can usually be obtained from rope-warehouses, and is kept by some fish salesmen.

(3) Rabbit or other land nets can be treated as just explained, but the nets should be well wetted in plain water first. First put the nets to soak in water, then make a 10 per cent. solution of cutch (catechu) or gambier. Put this in the vessel with the water to cover the nets, and after putting the soaked nets in it, let the whole stay overnight. The next day remove the nets and put them in a bath of water containing 4 per cent. of bichromate of soda or potash, lukewarm, and move them about in this for half an hour. Now wash the nets in plain water and dry in the air. They will have assumed a nice brown tan colour. The percentages are based on the weight of the goods. It should be noted that the chief points are: To well wet the nets first and squeeze out excess water; put the nets direct from the first to second bath, not putting them in water between.

(4) Such nets as those used for tennis and cricket can be preserved with tar. Take 1 part of *wood tar* and thin it with 4 parts of benzine, in a tub. Dip the nets in, work them about a little time to let the solution penetrate, then hang in the air to dry.

(5) An American journal states that fishing nets can be preserved by steeping them in melted paraffin wax.

OILS AND FATS.

(*See also* CANDLE-MAKING, LUBRICANTS, PAINTS, SOAP-MAKING, *and* VARNISHES.)

THE following information is condensed from the Cantor Lectures of Dr. J. Lewkowitsch by permission of the Royal Society of Arts.

Vegetable Oils and Fats.—The modern processes of obtaining oils divide themselves naturally into two classes—

I. Recovery of oils by expression.
II. Recovery of oils by extraction with volatile solvents.

Common to both processes is the machinery required for the preliminary treatment of the fruit or seeds.

Recovery of Oils by Expression.—The seed entering the oil mill from the silos is reduced to "meal" on passing through crushing machinery. The comminuted seed is either expressed in this state (production of oils for edible purposes), or conveyed by means of an elevator into a kettle in which the seed is warmed (production of oils for manufacturing purposes) by means of steam which causes the cells to burst rapidly, renders the oil more fluid, and perhaps also helps to coagulate some albuminoid matter, all these operations combining to facilitate the subsequent moulding of the meal into cakes.

On opening a slide, an exactly measured quantity of heated seed then falls out, and drops into a measuring box. On being drawn forward this allows the seed to fall on to a press-cloth of the desired shape of the oil-cake. By a preliminary pressing sufficient consistence is given to the cake, so that it can be carried wrapped in the cloth to the hydraulic press. This consists, in one system of seed-crushing, of an open press, fitted with about 16 iron press plates, between which the cakes are inserted by workmen. The press is packed with cakes

until full; the ram is then driven up by machinery, at first with the help of an accumulator, and finally by hydraulic pumps. The oil exudes from the meal, drains off, and is collected in tanks below the press or set of presses which are generally arranged in a battery of four presses. After releasing the pressure the cakes are taken out and the edges which are soft and oily are trimmed off in a cake-paring machine. Obviously the cakes retain a certain quantity of oil, and in the case of those seeds which contain a large amount of oil, such as castor seed, a second expression is required. In such cases the hard cakes are broken up in a cake-breaking machine, whilst the softer cake-parings are triturated in a special machine, or an edge-runner mill is used for the same purpose.

The first expression of seeds that are rich in oil, such as those containing more than 40 per cent., leads to some difficulties in the open hydraulic press since the oily meal causes "spueing," i.e. the soft mass is apt to exude through the cloth. Hence in modern installations, seeds of this kind are frequently expressed in a "clodding-press," i.e. a hydraulic press provided with a circular box or cage into which the material is filled. The box is either constructed of metal staves (vertical steel bars), held together by a number of steel rings, or consists of a cylinder having a large number of perforations.

Recovery of the Oils by Extraction with Volatile Solvents.—The second class of processes for obtaining oils and fats from fruits or seeds is represented by the so-called "extracting processes," and is very largely employed in the extraction of olive-oil, marc and palm kernel oil from palm kernels, rape-oil from rape seed, and castor-oil from castor seed.

The solvents employed on a large scale are almost exclusively petroleum ether and carbon bisulphide; ordinary ether must be considered as altogether outside the range of the solvents used on a large scale owing to the considerable loss of solvent involved, and furthermore on account of the great danger of fire. The same danger attaches, although in a somewhat minor degree to the employment of petroleum ether. More diminished still is the danger of an inflagration in the case of carbon bisulphide; as this solvent is heavier than water, the vapours are less liable to come in contact with an open flame. Hence, carbon bisulphide is largely employed for the extraction of oil, notably for the extraction of the marc of olives. Still, owing to the physiological effect this solvent has upon the workmen, coupled with the danger caused by the action of impure carbon bisulphide on iron, which has frequently led to conflagrations, the employment of carbon bisulphide is restricted.

An ideal solvent would be carbon tetrachloride, which is non-inflammable and has the further advantage of being heavier than water. Its high price has, however, hitherto prevented its technical application. Furthermore, its physiological effect (similar to that of chloroform) on the workmen would seem to prevent its general application.

The type of apparatus employed on a large scale depends on the temperature at which the extraction is carried out. In the case of cold extraction (preferable as regards fire risk), the seed is placed in a series of closed vessels, through which the solvent percolates on the counter-current system. The battery of vessels is so arranged that any one vessel can be made the last of the series, ready to discharge the extracted meal, and to be refilled with fresh meal, so that with the exception of the time required for charging and discharging, the process is practically a continuous one. The solution of extracted oil or fat is then transferred to a steam-heated still, where the solvent is driven off and recovered by condensing the vapours in a cooling coil. Thus the same quantity of solvent is used over and over again. The last traces of volatile solvent in the oil or

fat are driven off by a current of open steam which is blown through the hot oil or fat. The extracting processes in the hot are carried out in a special apparatus.

The principle involved in more elaborate forms of plant employed on a large scale is exemplified by the well-known Soxhlet extractor. The extraction here takes place continuously with a limited amount of solvent charged once for all into the apparatus. When the seed is deemed completely exhausted, the vessel containing the seed is disconnected by closing taps between the oil-containing vessel and the condenser, so that the volatile solvent can be immediately distilled off and condensed, whilst the seed-containing vessel is freed from the last traces of volatile solvent by open steam, and emptied and recharged with fresh seed. More compact still are extractors illustrated by that form of laboratory apparatus in which the meal-containing vessel is placed inside the flask charged with the solvent. Thus, in some form of extractors, a basket containing the crushed seed is placed on a support at some height above the bottom of the vessel charged with the solvent, so that on heating, the vapours of the solvent pass through and round the seed, whilst that portion which leaves the vessel in form of vapour is condensed in a separate condenser from which the liquefied solvent falls back and percolates the seed. Finally, when the meal is exhausted, the solvent is driven off, and the condensed solvent collected in a separate vessel.

In special cases, notably so in the case of olive-oil, a combination of the two processes described commends itself. The combined method consists in expressing most of the oil in the cold (for edible purposes), and then extracting the partially expressed material with volatile solvents, in order to recover the oil left in the press cakes. This combined process is known on the Continent under the name "huilerie mixte."

Animal Oils and Fats.—Animal oils and fats are usually obtained in a very simple manner by heating those parts of the animals which contain the oil or fat, so as to cause bursting of the fat-containing cells. The older rough and ready methods of heating the adipose tissue over free fire may be considered as almost extinct in this country, but it is still being practised in small establishments on the Continent. The nuisance which follows in the wake of a manufacturing process of this kind has naturally led to stringent regulations on the part of the sanitary authorities.

The rendering of tallow from the "rough fat," as it comes from the slaughterhouses to the rendering establishments, is now carried out under such conditions that no serious objections can be raised from a sanitary point of view. The simplest method for obtaining tallow for technical purposes, is to throw the rough fat into covered lead-lined vessels provided with steam coils, outlet taps, a trap-door for charging the rough fat, and a wide outlet through which any offensive vapours that may be given off are conducted through closed pipes to the chimney stack, or boiler, or fire grate. Hot water is then run on to the fat, and the steam turned on. After heating for a sufficient length of time the steam is shut off, when the clear melted fat rises to the top. It can then be drawn off ready for use, or into another vessel for further purification (refining, bleaching). The animal tissue, etc., still containing considerable quantities of fat, is boiled up again with steam, after a few per cent. of dilute sulphuric acid have been added, whereby the cell membranes are "cut," so that they part more readily with the remainder of the occluded fat.

A number of apparatus have been designed in which the tallow is melted in closed vessels under pressure. Such vessels—termed digesters—consist essentially of a vertical boiler provided with a false perforated bottom, and

constructed to withstand a pressure of several atmospheres. Live steam is turned into the boiler below the perforated bottom on which the rough fat rests. At the elevated temperature the mass parts readily with its occluded fat, and in a shorter time than by steaming at the ordinary pressure. The first apparatus of this kind (designed by Wilson) has served as prototype for a number of more or less complicated digesters now in use.

The rendering of lard in the large packing-houses in the United States is carried out on similar lines.

Purification.—The oils and fats thus obtained are in their fresh state practically neutral. If care be exercised in the process of rendering animal oils and fats, the fatty matter is very often sufficiently pure to be immediately worked up in those industries to which they serve as raw materials. If, however, they are allowed to remain in contact with animal tissue, they are liable to very rapid deterioration. Thus, freshly rendered lard or suet, or even whale oil, will keep sweet for a very long time if protected from light, air, and moisture, whereas the same materials through prolonged contact with putrescible animal matter become dark in colour, and rich in free fatty acids.

The vegetable oils obtained by expression contain frequently mucilaginous matter and other impurities, such as vegetable fibres, which pass through the press cloths. There are also admixed with the oils traces of moisture, which render them somewhat turbid, dark, and unfit for immediate use; not only for the table, but also for manufacturing purposes. Formerly these impurities were removed from edible oils, such as olive-oils, by the simple method of allowing the oils to rest for some length of time, when the moisture and the mucilaginous matter, etc., would settle out. This crude process is no longer employed in large establishments, the clarifying of the oils being much shortened by filtering through a filter press, or brightening by blowing with air.

Other crude oils require more elaborate purification (refining) before they are placed on the market. Notable examples of this kind are cotton-seed-oil and rape-oil. A sample of Egyptian crude cotton-seed-oil expressed direct from the crushed seed may range in colour from a ruby red to almost black, due to the dark brown colouring matter contained in the cells of the cotton seed. The oil is refined by treatment with dilute caustic soda; the latter combines with the colouring matter and the free fatty acids in the oil and forms a precipitate which falls down on standing, leaving the oil clear and bright. This crude rape-oil, again, is refined by treatment with concentrated sulphuric acid, and yields the refined oils.

Bleaching. — The methods of bleaching or decolorising oils also vary with each kind of oil or fat. A brief description may be given of the methods employed.

Bleaching by sunlight, one of the oldest processes, is naturally only feasible on a small scale, as the length of time and the space required to expose as large a surface as possible must naturally be costly. Still, in some cases, as in the bleaching of beeswax or in the bleaching of linseed-oil for artists' use, this method is being practised. Since the fatty matter undergoes practically no change, the products do not suffer as much as they would in the chemical processes of bleaching.

Bleaching by the aid of chemicals requires great circumspection, the object of bleaching being merely to destroy foreign substances, which impart a dark colour, or other undesirable properties to the oil or fat. The chief attention of the operator must therefore be directed to so treating the raw material that the fatty matter itself is not acted upon. For this purpose, the amount of chemicals must be limited to the smallest possible quantity, the temperature at which

they are allowed to act must be as low as possible, and the time of interaction must be as short as possible.

General methods of bleaching chemically, are—(1) Bleaching by means of oxygen; (2) bleaching by means of chlorine.

(1) Bleaching by means of ozone or oxygen gas is still too uncertain a process to be widely used on a large scale, and is only practised in some special instances. I have examined several ozone processes, but although at the first moment they seemed to effect the bleaching satisfactorily, yet after a time the oils darkened, or, as the technical term runs, the colour "reverted."

Bleaching by means of oxygen *in statu nascendi* is chiefly effected by employing manganese dioxide or potassium bichromate and sulphuric acid.

(2) In the processes of bleaching by means of chlorine, bleaching powder, or potassium bichromate and hydrochloric acid are used.

No general rule can be laid down as to which process should be employed in each given case, although it may be stated that tallow is best bleached by means of manganese dioxide, and palm-oil by means of bichromate and hydrochloric acid.

The object of bleaching is not only to remove colouring matters for the time being, but to remove them so efficiently that the colour, or even a dark shade, will not "revert" some time after the fat or oil has been bleached. Patents claiming to effect this object appear annually in great numbers, and disappear again when experience has shown that the colouring matter does "revert" to a larger or smaller extent after the material has, e.g. been converted into soap. Thus one of the simplest and most frequently practised processes, that of bleaching tallow, does not produce soaps as good in colour as those made from the freshly rendered tallow. Not only must each kind of fat or oil be considered a special problem, but frequently different varieties of one and the same oil are apt to cause the same difficulties as would a new oil or fat. To mention an example, the bleaching of the softer kinds of palm-oil, such as "Lagos" or "Old Calabar," offers very little difficulty. But the harder kinds of palm oil, such as Congo oil, have hitherto withstood all attempts to bleach them.

The above methods of bleaching are, however, inadmissible in the case of those oils and fats which are intended for *edible purposes*. In these cases we must rely chiefly on physical methods. The oils intended for edible purposes must not even be expressed while hot, and the employment of chemicals involving the use of acids must be altogether excluded, as they impart an objectionable flavour which would render the product useless for edible purposes. Treatment with alkalies in one form or another can only be resorted to in a very moderate degree as, for instance, in the refining of cotton-seed-oil for the table.

The absence of free fatty acids in edible oils and fats is a very important desideratum. Hence, in all refining processes, the complete removal of free fatty acids and of the objectionable products which seem to follow in the wake of the once formed free fatty acids, namely, those which impart to the oil the properties we comprise under the term "rancidity," is the chief aim of the manufacturing processes. Alkalies and alkaline earths are almost exclusively used for these purposes.

The physical method consists chiefly in filtering, with a view to brightening the oils by the removal of the adhering moisture and suspended matter of an albuminoid character, and, if colouring matter is to be eliminated at the same time, in treating with either charcoal or fuller's earth. The latter process is, of course, followed by filtration, in order to get rid of the charcoal or fuller's earth, which absorb and retain the colouring matters.

A further requisite of edible oils is that they should not congeal at temperatures near the freezing-point,

Most olive-oils practically fulfil this demand. In the case of cotton-seed-oil, however, which is at present used in enormous quantities as an edible oil, or for adulterating high-class edible oils, a solid portion, termed "stearine," separates out at a temperature of about 50° F.

In order to render cotton-seed-oil suitable for the table, this "stearine" is removed; as the technical term runs, the oil is "demargarinated."

Originally the process of "demargarination" was a natural process, and consisted in allowing the oil to stand in large vessels during the winter, when the "stearine" settled out as a solid mass at the bottom of the vessel, so that the supernatant clear oil could be drawn off. Hence, such "stearine-freed" or "demargarinated" oils are designated "winter oils."

This simple process has, however, become too expensive, owing to the large amount of capital locked up in the enormous quantities of cotton-seed-oil that had to be stored. Hence, more rapid processes have been introduced. These consist in artificially refrigerating the oil, and filtering off the "stearine" through filter-presses, or removing it by pressure in hydraulic presses. It need hardly be added that in the latter case the whole process must be carried out in artificially cooled rooms.

Through the introduction of demargarinating processes, oils which were objectionable as table oils on account of their separating "stearine," are being added to the range of edible oils. Such oils are arachis oil, and notably that class of Tunisian olive-oils which hitherto could not be mixed with the finest Italian and French olive-oils, owing to their being exceptionally rich in "stearine."

Margarine.—Margarine consists chiefly of a mixture of animal and vegetable fats. The animal fats are prepared from the freshest beef fat or hog fat. That obtained from beef fat is known as "oleomargarine"; that from hogs—neutral lard—is chiefly employed in the United States. The vegetable oils are cotton-seed-oil, arachis oil, and sesamé oil. The vegetable oil must be devoid of free fatty acids and should not possess any unpleasant flavour. Thus, neither maize oil, nor even cotton-seed-oil, can be used for the finest and best brands of margarine, as the particular flavour of these oils would be noticeable in the finished product.

For the production of oleomargarine, the rough fat is removed from the slaughtered animal as quickly as possible and brought into the works, where it is sorted and the kidney fat is selected. This is carefully washed with warm water and thoroughly cleaned. The cleaned fat is then brought immediately into large, well-aired, artificially cooled rooms to dry and harden, being allowed to hang there suspended from tin hooks for several hours. Another process to secure rapid hardening is to immerse the fat first into iced water.

The hard fat is next cut up and shredded in a shredding machine, and then ground between rollers. The disintegrated mass is immediately introduced into tin-lined, jacketed vessels, at a temperature not exceeding 45° C., this temperature being maintained by hot water contained in the jacket.

At the temperature of 45° C., only a portion of the fat contained in the animal tissues separates on the top of the comminuted rough fat. The settling and clearing is assisted by scattering salt over the surface of the melted fat. This melted portion, appropriately termed "premier jus," is carefully syphoned off and run into clean barrels to be sent to the margarine works proper for further treatment. The "premier jus," is not the whole of the fat contained in the charge, but only the first portion that will exude at a temperature of 45° C.; the remainder of the fat is recovered from the scraps for other purposes which do not interest us here.

If the margarine be produced in the

same works, the "premier jus" is allowed to run into shallow, tin-lined trays, arranged in tiers in a cooled room, when the bulk of the "stearine" separates out in a crystalline condition. For the best qualities of margarine, the "premier jus" is remelted, and allowed once more to settle out, after salt has been added, whereby the last traces of membrane and tissue are precipitated. The cleared fat is allowed to run into large vats, in which it stands from three to five days, at a temperature suitable for the crystallisation of the "stearine."

The crystallised mass from the tins is immediately cut up into small pieces weighing about 3 lb. each. These are wrapped in canvas cloths, and are then put into hydraulic presses. In large works, where the "premier jus" has been allowed to crystallise in huge vats, the whole crystallised mass is stirred up into a homogeneous pulp which is wheeled to the presses and packed into them in small pieces, wrapped in canvas cloth, holding about 3 lb. each.

The oleomargarine—"oleo-oil," as it is termed in the United States—runs out into tanks below the presses, to be worked up for margarine. The solid portion which remains in the presses is sold as tallow stearine.

This oleomargarine is the chief raw material for the manufacture of butter substitutes. It is mixed in special churning machines of the various types, with vegetable oils and fats and milk.

The milk department forms, therefore, a substantial portion of the margarine works. On its arrival from the farms the milk must be "pasteurised." As a rule the cream has been taken off before the milk reaches the works, otherwise it is removed by means of a centrifugal machine.

The milk is run, together with the melted oleomargarine and the vegetable oils admixed in accurately weighed off proportions, into churns, in which the whole mass is thoroughly blended. The churning machines consist of oval jacketed vessels, provided with one or two sets of stirring and mixing gear. During the process of churning a constant temperature is maintained by means of steam sent through the jacket of the churn. The object of churning, besides thoroughly mixing the ingredients, is to destroy the tendency of the oleomargarine to crystallise, and to produce a complete emulsion by pulverising the mixture into single globules, such as butter fat forms in milk. When the mass is thoroughly churned, the steam is turned off, and the warm material is cooled by cold water sent through the jacket.

From the churn the cooled margarine is run through wooden shoots into cooling tanks. Whilst running out of the churn the margarine is met in the shoots by a current of ice-cold water, delivered under high pressure, so that the mass is completely pulverised. The disintegrated globules, after solidifying, somewhat resemble butter granules.

In small works the cooling tanks are built of marble; in larger works they simply consist of large wooden tanks. In other works they form very large storage vessels, built up of tiles.

The solidified margarine is taken out by spades, or by long-handled wooden spoons, and placed in wooden wagons, where the admixed water is allowed to drain off. These wagons are conveyed to large kneading-machines, consisting of huge, circular wooden tables which rotate slowly, whilst at the same time a set of conical, fluted, or specially-shaped rollers move along the top of the revolving tables. The margarine is slowly but thoroughly worked through, so that the particles become homogeneous throughout the whole mass. At this stage colouring matters are admixed.

The margarine is then salted to taste, and submitted to a further thorough kneading and mixing either on a similar machine, or in a specially-constructed churning machine.

The margarine is finally moulded

into lumps, pats, rolls, or any other desired shape. Like butter, margarine contains water; the proportion of this should however not exceed 10 to 12 per cent. in well-made preparations.

The object of the margarine manufacturer is, naturally, to make his product resemble butter as nearly as possible. In order to take away the "tallowy" or exclusively "fatty" taste of the material, some manufacturers, provided the law permit, add butter itself. Others add small quantities of butyric acid, or specially prepared compounds.

An important point is to produce margarine which will froth and "brown" when heated, so that even in cooking the nearest approach to butter is reached. As the property of butter of "browning" and frothing is due to caseïn and milk sugar, it is evident that the more milk is used in the manufacture of margarine, the nearer will the product approximate to butter. This expedient is largely used in this country, but on the Continent, where the law forbids the addition of more than a strictly limited quantity of milk, or its corresponding quantity of butter-fat, a number of curious patents have been taken out for substances purporting to impart the desired property to margarine. Caseïn and other albuminoids are prominent amongst them. Even the use of beeswax and vegetable waxes has been patented, although the employment of such substances must be deprecated, as they seriously reduce the digestibility of margarine.

Lard Substitutes.—The manufacture of lard substitutes is in many respects similar to that of butter substitutes, although it is much simpler, since lard substitutes contain no water, and merely represent a mixture of fats. The basis of the lard substitutes should be, of course, lard, with which other oils and fats, such as cotton-seed-oil and beef fat are intermixed in the melted state.

The enormous quantities of lard substitutes that are produced necessitate rapid cooling of the mass. The simple process of allowing to cool spontaneously in large vessels is too expensive; hence, special cooling machinery is employed.

In the early days of this industry the manufacturers of lard substitutes sailed more closely to the wind than the margarine manufacturer. The lard substitutes sold under such names as "refined lard," "compound lard," were frequently found to contain no lard whatever, being nothing else than judiciously prepared mixtures of beef stearine—the by-product of the margarine manufacture—and cotton-seed-oil and other vegetable oils. Here also legislation has had to step in to protect the public.

The detection of cotton-seed-oil in lard became, therefore, one of the most important problems of the public analyst. A rapid means of detecting it is Halphen's test, which reveals the presence of cotton-seed-oil by a red coloration. However, too much reliance should not be placed on a rapid test like this, since the adulterator has always been able to keep pace with the latest discoveries of science, and has succeeded in nullifying the indications of this test by treating cotton-seed-oil in such a manner that it no longer shows the characteristic red coloration. Moreover, some help has accrued to the adulterator through the fact that lard from hogs fed on cotton-seed cake exhibits a colour reaction similar to that which lard shows which has actually been adulterated with cotton-seed-oil.

Vegetable Butter.—A third kind of edible fats manufactured on a large scale are *vegetable butters* and the hard fats derived therefrom, which I comprise under the name "*chocolate fats.*" Vegetable butters were first made from cocoa nut oil and palm nut oil, and prepared for the Indian market, where the native population are forbidden by their religious tenets to consume animal fats. Latterly this vegetable butter has, under a variety of fancy

names, such as "lactine," "vegetaline," "cocoaline," "laureol," "nucoline," "albene," "palmine," "cocose," etc., found extensive use at home in confectionery and in the manufacture of margarine, and—it must be feared—is also finding a growing outlet for adulterating cow's butter. From these vegetable butters "chocolate fats" are obtained. The natural chocolate fat is, of course, "cacao butter," which is expressed from the cocoa beans in the course of preparing cocoa. As more cacao butter is obtained from the bean than a properly constituted chocolate should contain, a surplus of cacao butter accumulates in a cocoa works. This surplus is worked up into cheaper kinds of chocolate. Thus a demand has been created for cacao butter. As the natural supply does not suffice, and moreover as cacao butter is the most expensive fat, being even dearer than ordinary cow's butter, there soon arose a demand for a cheap substitute of genuine cacao butter.

Animal fats, such as tallow, are unsuitable for chocolate manufacture, as if not very carefully refined they are apt to impart an unpleasant flavour ("animal flavour") to the finished chocolate.

The best chocolate fat substitutes must, therefore, be prepared from vegetable fats. At present the most suitable substitutes are manufactured from cocoanut and palm nut oils, by removing the softer portions of cocoanut and palm nut oils in a similar manner as is done in the case of working up the "premier jus." The cocoanut and palm nut oils are allowed to crystallise at a slightly elevated temperature, and the crystallised mass is expressed in hydraulic presses. Whereas in the manufacture of oleomargarine the liquid portion is required, in the present case the hard mass left in the press, termed "cocoanut stearine," or "palm nut stearine," is the desired product.

These chocolate fats have the drawback that their melting point is somewhat low. Of course, the more of the softer portion is expressed from the cocoanut oil and palm nut oil, the higher will be the melting point. But since the brands having a high melting point are somewhat costly, products of lower melting point find ready entrance into chocolate works, and it is therefore easy to understand why so many kinds of chocolate become soft in the pocket, or even when held in the hand.

In order to impart greater hardness to the chocolate fats they in their turn are "stiffened," i.e. adulterated with small quantities of animal fats, such as tallow, tallow-stearine, etc. It has even been stated that Japan wax is admixed in order to raise the melting point. Also mineral waxes like paraffin wax, ceresin, have been admixed for "stiffening" purposes, but these should be totally excluded as they are indigestible.

The preparation of suitable chocolate fats from vegetable fats of a higher melting point than cocoanut oil or palm nut oil would, in my opinion, bring us nearer to the solution of the problem. I would suggest for this purpose the working up of some tropical vegetable fats, such as margosa oil, mowrah seed oil, etc.

Boiled Oils.—The value of the drying oils rests on a remarkable property they possess, viz. that of absorbing oxygen from the air. Linseed-oil is capable of taking up as much as 20 per cent. of its own weight in the course of about three days, passing from its oily state through an intermediate stage of a viscous, then tacky substance, until it is converted into a thin, elastic, flexible skin. The rapidity of drying can be much accelerated by the process of "boiling" the oil, that is, heating the oil with certain metallic oxides to a high temperature.

Although several centuries have elapsed since this discovery was made, we are still unable fully to understand the chemical change which takes place when an oil boiled with metallic oxide dries.

For some time it was assumed that

the oil itself became oxidised, the glyceridic part of the oil being attacked in the first instance. But this view must be rejected as erroneous, since "boiled" oil retains almost its whole quantity of glycerin. Moreover, practice has almost shown that the glyceridic part of boiled oil is a necessary ingredient, and several attempts, for which patents have been taken out, to prepare boiled oils from the fatty acids after the removal of the glycerin, have led to useless products. The explanation was then suggested that the metallic oxides act as oxygen carriers during the boiling, but the process of boiling certainly does not consist in an oxidation of the oil, since if oxidation really does take place, it cannot exceed a very slight amount. In the investigation of an ozone process, I have noticed that oils treated with oxygen acquire all the properties of boiled oils although chemically speaking they had undergone a very slight change only.

Furthermore, recent progress has shown that a high temperature is not required for the preparation of boiled oils, as we are able to obtain oils having the property of boiled oils by carefully grinding linseed-oil in the cold with manganese borate.

Much lower temperatures than are required in the old process of boiling have been found sufficient. Thus at present the bulk of the boiled oils is obtained by heating linseed-oil with driers to a temperature of 150°C. only. The process is carried out by introducing the oil into a cylindrical vessel, provided with a heating coil and an agitating gear, so as to produce an intimate intermixture between oil and drier whilst they are heated to the desired temperature.

The temperature employed in boiling can be still further lowered since modern driers have been introduced, especially those known as *liquid driers*. These liquid driers consist of a solution of lead linoleate or even of resinate in boiled oil or linseed-oil.

These driers, especially the liquid driers, have led to a great deal of secretmongering. They are sold under a variety of fancy names of which the best known is perhaps "terebene." A few per cent. of these driers added to linseed-oil at temperatures of 120°–150°C. is able to impart to the oil the properties of boiled oil. The mania for cheapening has even gone so far that "boiled" oils are prepared by merely pouring a solution of these driers into linseed-oil in the cold. Such oils, which the Americans in their characteristic jargon call "boiled through the bunghole" are distinctly inferior to oils prepared by the aforementioned processes.

Now, if a mere dissolving of the drier in the oil is sufficient, then no important chemical change can have taken place. Yet the only explanation which commends itself at present, and in support of which I have published elsewhere a number of experiments, is that the oil becomes polymerised. The first outward sign of this consists in the oil acquiring a higher specific gravity. This explanation gains support in the fact that by merely heating linseed-oil without any driers an increase of specific gravity, or polymerisation, takes place.

Another illustration of a far-reaching polymerisation is given by the example of *tung oil*. If this oil is heated to 180° C. for several hours, or to 250°C. for a short time, it solidifies to a jelly-like mass.

The boiled oils find extensive employment not only in our ordinary paints; enormous quantities are used in the *varnish industry*. The theory of this manufacture is simple. It consists in dissolving suitably-prepared gums and resins in linseed-oil and "boiling" the mixture. The "varnish oil" so obtained is thinned down with oil of turps.

Oxidised Oils.—*If the oxidation of linseed-oil is carried further until the maximum amount of oxygen is absorbed, we obtain the "solid linseed-oil" representing an elastic jelly-like mass.* It is prepared by allowing lin-

seed-oil previously boiled with a drier so as to accelerate the oxygen absorption, to run over a light cotton fabric—"scrim"—hanging from the ceiling of a high building kept at a temperature of about 100°F., so that the oil, whilst trickling down from the top of the house, is capable of absorbing rapidly the maximum amount of oxygen. A portion of the oil solidifies on the fabric, the oil which drains off at the bottom being pumped up again, and allowed to run down, until the layers of the solid mass have reached, after several weeks, a thickness of about half an inch. This process is termed the "scrim process;" the solidified oil obtained by this method is termed "scrim oil."

Another method consists in passing a current of oxygen through linseed-oil mixed with a small percentage of drier in a closed jacketed vessel heated by steam, until the maximum amount of oxygen has been absorbed. The hot mass will still run, but after cooling it sets to a jelly-like mass which is dry enough and solid enough to be packed into bags. These materials form one of the chief ingredients of "linoleum," the invention of Walton and his successors. For this purpose, the "scrim oil" is mixed with rosin and ground cork, rolled on a jute canvas backing, and is finally seasoned at a temperature of 75° F. before it is placed on the market in its well-known form.

Vulcanised Oils.—If in the last described process we substitute sulphur for oxygen, we obtain that class of oils which are best described as "vulcanised oils." The treatment is similar to that which india-rubber undergoes in the vulcanising process, and just as in india-rubber vulcanising we have two processes, viz. the "hot cure" (treating the india-rubber with sulphur at a high temperature), and the "cold cure" (treating with sulphur chloride at a low temperature), so we can produce the vulcanised oils either by treatment with sulphur at a higher temperature, or with sulphur chloride at the ordinary temperature.

The reaction is almost instantaneous in the case of castor-oil.

Other oils, such as linseed-oil and rape-oil, require a little longer time, and a somewhat elevated temperature. The products so obtained have acquired commercial importance. They form a mass possessed of not very great elasticity; and are chiefly employed to adulterate ("cheapen," as it is called) india-rubber goods. The great deterioration which india-rubber goods exhibit (during the last decade or two) is due to the extensive employment of these substitutes.

Sulphonated Oils.—Oils and fats undergo a somewhat deeper change, when they are treated with concentrated sulphuric acid. They combine with this acid and form water-soluble products. On this reaction is based the industry of *turkey-red oils.*

This class of oils is prepared by allowing concentrated sulphuric acid to run into castor-oil slowly, with constant stirring, taking care that a temperature of 35° C. is not exceeded. The product is then mixed with water and allowed to settle out; the lower layer is drawn up and washed with a solution of sodium sulphate until the acid is practically removed. Finally ammonia is added until the sample gives a clear solution with a small quantity of water.

At times, when castor-oil was high in price, cheaper substitutes, such as cotton-seed-oil, etc., were used. At present, however, the price of castor-oil is so low that it would not pay to employ anything but the genuine oil.

PACKING AND STORING.

(*See also* PRESERVING *and* REFRIGERATION.)

Glass and China.—The safety of glass articles packed together in a box does not depend so much upon the quantity of packing material used, as upon the fact that no two pieces of glass come into actual contact. In packing plates, a single straw placed between two of them will prevent them from breaking each other. In packing bottles in a case, such as the collecting case of the microscopist, and the test case of the chemist, rubber rings slipped over each, will be found the best and handiest packing material. They have this great advantage, that they do not give rise to dust.

One of the most important things is to season glass and china to sudden change of temperature, so that they will remain sound after exposure to sudden heat and cold. This is best done by placing the articles in cold water, which must gradually be brought to boiling, and allowed to cool very slowly, taking several hours. The commoner the materials, the more care is required. The best glass and china are well seasoned before sold. Such wares may be washed in boiling water without fear of fracture, except in frosty weather, when, even with the best, care must be taken not to place them suddenly in too hot water. China that has any gilding may on no account be rubbed with a cloth of any kind, but merely rinsed first in hot and afterwards in cold water, and then left to drain till dry. If the gilding is very dull and requires polishing, it may now and then be rubbed with a soft wash-leather and a little dry whiting; but this must not be more than once a year, or the gold will be rubbed off and the china spoilt. When put away in the china closet, pieces of paper should be placed between them to prevent scratches on the glaze or painting, as the bottom of all ware has little particles of sand adhering to it, picked up from the oven wherein it was glazed. The china closet should be in a dry situation, as a damp closet will soon tarnish the gilding of the best crockery. In a common dinner service, it is a great evil to make the plates too hot, as it invariably cracks the glaze on the surface, if not the plate itself. We all know the result—it comes apart. The fact is, when the glaze is injured, every time the "things" are washed the water gets to the interior, swells the porous clay, and makes the whole fabric rotten. In this condition they will also absorb grease, and, when exposed to further heat, the grease makes the dishes brown and discoloured. If an old, ill-used dish be made very hot indeed, a teaspoonful of fat will be seen to exude from the minute fissures upon its surface. These latter remarks apply more particularly to common wares. As a rule, warm water and a soft cloth are all that is required to keep glass in good condition, but water-bottles and wine-decanters, in order to keep them bright, must be rinsed out with a little muriatic acid, which is the best substance for removing the "fur" which collects in them. This acid is far better than ashes, sand, or shot; for the ashes and sand scratch the glass, and if any shot is left in by accident the lead is poisonous. Richly cut glass must be cleaned and polished with a soft brush, upon which a very little fine chalk or whiting is put; by this means, the lustre and brilliancy are preserved. ('Boston Journal of Chem.')

Deliquescent Salts.—(1) Lime chloride and other deliquescent salts may be packed in shaving paper, in cardboard boxes, pasted up and then well soaked in melted wax, paraffin, etc.

(2) The difficulty experienced in preserving caustic soda in a powdered state, owing to the tendency of its particles when exposed to the atmosphere, to deliquesce and combine and mass together, is said to be overcome by mixing with the soda a quantity of

powdered sand sufficient to protect the particles of soda from such contact with each other as will cause them to mass together, and also sufficient to shield, in a measure, the particles of caustic from contact with the atmosphere. Caustic soda thus treated is applicable generally in the arts, and can be handled with greater facility than the ordinary commercial article. Where it is to be used as a flux in the manufacture of cast iron, 1 part ground sand may be used to 5 of ground caustic soda; but the quantity of sand may be materially increased, though a less amount will not prove effective. While the sand operates in a measure to protect the soda from atmospheric influences, and prevent contact of its particles, there is no chemical combination between the sand and soda which would cause it to solidify and harden, as would be the case were powdered limestone, for instance, used. In practice the soda and sand are ground up to a powder, either separately or together, and immediately mixed. From the facility with which the article prepared can be handled, it is specially adapted for use as a flux in the manufacture of cast iron, though for the same reason it also commends itself to the trade generally.

Phosphorus. — Phosphorus should be kept in a place where no damage can result in case the water, in which it is packed, should leak out, and the air obtain free access to it. This is the general rule; its practical application may vary with the circumstances. The governments on the continent of Europe usually prescribe that it must be kept in the cellar, in a locked closet. It is often kept in strong vials, filled with water, which are stoppered with a good cork; and the vial is placed inside of a tin box provided with a well-fitting lid. Phosphorus is usually put up and sold in tightly soldered tin cans filled with water. These cans often begin to rust on the outside, and it will happen, occasionally, that the rusting process will penetrate through the tin, causing the water to leak out and producing a more or less slow, though sometimes quite rapid combustion of the phosphorus. This has sometimes happened when no person was present in the warehouse or storeroom, and has been the cause of several fires. The accident may be prevented by carefully *painting* the tin cans as soon as received, with several layers of white paint so as not to leave the least portion of tin exposed. Should a large stock have to be carried, it is advisable to paint the cans freshly at least once a year.

Fulminates.—These exceedingly dangerous compounds, liable to explode either by friction or concussion, are rendered safe by keeping them thoroughly immersed in water.

Explosive Fluids.—Petroleum is an example of several fluids heavier than water, which are liable to ignition or explosion, or both, when their vapour comes into contact with flame or a body at a high temperature. All such fluids (for instance carbon bisulphide) may be rendered quite innocuous by storing them under a layer of water. A convenient tank for the purpose is shown in Fig. 83: *a*, space for mineral oil or other fluid to be stored; *b*, diaphragm; *c*, balance-pipe; *d*, filling and emptying pipe for fluid; *e*, inlet and overflow water pipe; *f*, vent-pipe; *g*, water layer above the fluid; *h*, water layer beneath the fluid. The tank is first filled with water by the pipe *d*, entering immediately under the diaphragm; the admission of water is continued until it has passed up the balance-pipe *c*, and filled the space *g*, driving out the air by the vent *f*. The petroleum or other fluid is then forced through *d*, displacing the water, which passes up *c* into *g*, the surplus escaping by the outlet *e*. When the vent *f* is closed, no air can mingle with the contents and no evaporation can take place. In order to draw fluid out, water is forced in by *e*.

With regard to the material for the construction of petroleum receptacles,

Dr. Stevenson Macadam states that lead will spoil lamp oil in a week or less; iron does not detract from the illuminating qualities, but deepens the colour and causes a rusty deposit; zinc, solder, and galvanised iron are all

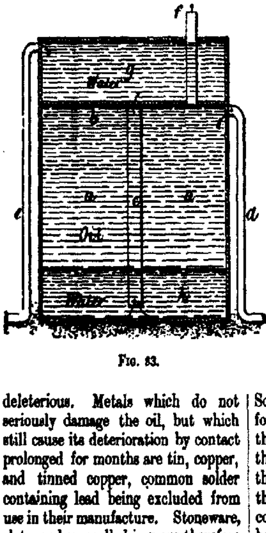


FIG. 83.

deleterious. Metals which do not seriously damage the oil, but which still cause its deterioration by contact prolonged for months are tin, copper, and tinned copper, common solder containing lead being excluded from use in their manufacture. Stoneware, slate, and enamelled iron are therefore recommended.

It has been asserted that the addition of a little powdered soapwort (*Saponaria officinalis*), digested in water, to petroleum causes it to form a solid mucilage, and that the subsequent application of a little phenol (carbolic acid) causes it to resume perfect limpidity.

Flowers.—Always cut the flowers early, in the cool of the morning, and when in their prime. Take a piece of cotton wool, wet it, and wring it out, then twist it about the stalk. If tin boxes are used, they must not have sharp corners, or they will be rejected at the post-office, but, when properly made, they excel all others for the purpose in question. At the bottom of one of these, place a piece of stout brown paper (if thin, double it); let this be well damped, then lay the flowers carefully in, placing a piece of "silver" or tissue-paper between them to prevent their bruising each other. Over all place a piece of the same paper, and on this a little cotton wool. Cover the box with paper. Modes of faulty packing may be mentioned as a warning against their adoption: (1) Placing the flowers in contact with dry cotton-wool, which clings to them, and abstracts their moisture; (2) putting them in tin boxes, such as have contained lucifers, etc., which invariably get crushed in passing through the post-office; (3) putting the cotton-wool about them too wet, the moisture from which gets shaken over the flowers and spoils their colours; (4) cutting the flowers after exposure to the sun, which ensures their falling to pieces on their journey, this also occurs if the blooms are stale. Some persons sending seedling flowers for an opinion, think it best to cut them when not fully open, knowing that they will expand in water; but they should learn they do not show their true character either in shape or colour, under such circumstances. A better plan is to cut off the pistil directly it can be done; this will ensure the flower lasting a considerable time.

Articles of Delicate Odour.—Hitherto the question of packing delicate goods has been viewed almost entirely from what may be called the strength-of-materials standpoint. Manufacturers and importers have found that ordinary packing material of a certain thickness and weight was sufficiently strong to withstand the blows received in transit, and have forthwith adopted this as the only condition necessary to be fulfilled in their packages, unless, indeed, anything cheaper should come into the market, in which case most probably it would be used instead. There is

one exception to this which has recently occurred. During the last few years there has been a decided increase in the demand for tastily and attractively packed goods—goods of all kinds, in fact, put into such packages that the eye of the purchaser should be attracted by the appearance. The natural result of this has been the employment of any and every material which was adapted to increase the ornamentation, regardless of whether it was adapted for preserving the contents from injury. Packages in which wood is used have given the worst illustration of this erroneous style of packing, green wood being frequently employed, partly, perhaps, because of its working more readily, and woods which either have or develop an unpleasant odour being used because of their pretty markings or suitable colour, while it has not been uncommon of late to employ some kinds of wood which are to a certain extent absorbent, and retain any smell with which they come in contact.

Oily or Greasy Materials.—Where goods of an oily or greasy character have to be packed, and the escape of the oil may to a considerable extent be attended with the risk of fermentation or rancidity, grease-proof paper, or some such packing has to be used, and up to the present this paper is unsatisfactory in character, indeed, unless very costly kinds are used.

Effect of Stowage on Board Ship.—In considering the question of export goods, we have, at the outset, to face the fact that goods stowed on board ship have necessarily to be packed in the hold, and to remain there for some time—it may be for weeks or even months—and that wherever the voyage may be to it is almost certain that the temperature to which they are subjected in the hold during nearly the whole time is far in excess of our ordinary English atmospheric temperature. To this must be added another fact which has a great bearing on the question, and that is that the atmosphere of the hold of a vessel is saturated with moisture, and very frequently *supersaturated*. Bilge water exists in small quantities in every vessel. Almost every cargo contains goods in such a state of moisture that they are capable of giving off moisture when the temperature is raised, and there can be few circumstances under which the air of a ship's hold, when the latter is stowed with cargo, will contain less than the full saturation amount of moisture. But the temperature of the hold must vary from time to time, very slightly, it is true, but probably a small diurnal variation of some 1° or 2° would generally appear. As soon as the diurnal, or perhaps more probably nocturnal, fall of temperature takes place, moisture in the form of dew or cloud would be produced and deposited upon the goods. This is not theory only, but a fact which has been noted in numbers of cases, for the moisture so deposited is always first found upon the top or upper surface of the packages. There is a great deal of importance in this saturation or supersaturation with moisture. Dry air has very little effect upon most natural products beyond a certain amount of desiccation, and its action upon metallic substances is very slight. Moist air, on the contrary, acts rapidly and energetically upon metallic bodies, and is the most active agent in setting up decomposition in organic bodies. This is not merely a surface effect, but depends upon the specific capacity which almost all organic substances appear to have for water. Leather, wood, tea, bark, straw, each absorb a certain definite amount of moisture corresponding to the variety of the article itself—not merely its species but its variety—and the moisture of the air in which it is placed. Thus, in the case of, say, 4 samples of tea, of four different kinds, if exposed to air saturated with moisture they will absorb more moisture than they previously contained, but when again exposed to air in what may be called its normal condition in this country—

that is, not saturated—the excess of moisture absorbed would be given off again, and while this excess is escaping into the atmosphere it may carry with it some of the aroma belonging to the goods themselves. Nearly everybody would admit that the alternately heating and cooling of any article with a delicate smell would injure that smell either in quantity or quality, or both, but it is equally true that alternately moistening and drying such an article—in other words producing such an effect as would be obtained by an exposure alternately to a supersaturated atmosphere and to an atmosphere not saturated with moisture—would have a like effect.

Dealing still further with the exterior of the package, this deposition of moisture in the form of dew on the exterior has another important effect. This water is precipitated in the air in the form of minute, almost infinitesimally small, water globules, and these have a strong solvent action on any gases or vapours which are present in the air, and which are thus in a more active condition when brought in contact with the goods on which the dew falls. Suppose the air in the hold of a ship to be impregnated, as it always is, with carbonic acid, and also slightly saturated with acetic acid generated from some source or other—the dew deposited on any change of temperature will become saturated with both carbonic and acetic acids, and will obviously be a dilute acid in the most suitable form for acting upon any metallic surfaces with which it comes in contact. Not only so, but leather or cloth goods may be rotted by such an action during a long voyage, and the causes may erroneously be put down to sea damage.

Tea.—The flavour of tea is not only most delicate and fugitive in character, but tea is remarkably prone to acquire any odour given out by surrounding materials. It is important, therefore, that it should be packed in air-tight cases. For this purpose nothing has been found more satisfactory than sheet lead, which itself requires a protective covering of wood. Care must be taken to select a wood not liable to rapid fermentation and decay under the influence of heat and moisture, as such decay has in many cases led to the formation of acetic acid which attacks the lead, forming white-lead. This action rapidly eats through the lead, admitting air to the interior of the package, and resulting in a great deterioration of the contents. Of late years a very excellent packing known as Venesta (in which the cases are formed of a double thickness of very thin wood fastened with the grains running at right angles), has come into use in many of the largest plantations.

Textiles.—The packing of textile fabrics for foreign markets is a subject which has received very great attention in this country, notably in Lancashire. Much depends upon the proper packing of goods, and frequently improper packing causes great losses, owing to the severity of various climates, in one way or another. The shape and weight of packages are both important, and each foreign market, as a rule, has its special peculiarities, which must be carefully considered when purchases are made up for delivery.

The main points in packing are (*a*) to properly compress goods into the smallest possible space without damage; (*b*) to so protect them from wet and wear as to have them reach their destination in perfect condition; (*c*) to have them suit the convenience, taste, and requirements of various foreign markets; and lastly (*d*) to do all this well at the least expense.

It is essential that packing should be done so as to economise space, and thus save freight charges, and to do this it is necessary to press the bales into the smallest size possible without injuring the goods. Another important point is to have the goods packed so that a large bale can be separated into smaller complete packages, in order that they may be placed on

mules or other beasts of burden, which are yet the common carriers in some countries. In the case of sized goods, there are many considerations to be kept in mind, such as the quality of the paper, the kind of cloth for covering, and the material out of which these are manufactured. Mildew is common in sized goods, and great care is always necessary in packing the same. In fact, unless the ingredients used in the sizing are of the proper quality and quantity, some sort of growth in the bale is pretty sure to follow, no matter how well the goods are packed. There are fashions, so to speak, in packing goods for some foreign countries, notably in the South African trade, where even the colour of the iron hoops on the bale is important. There was an instance where a consignment of cloth in red hoops sold at once, but another lot of precisely the same goods could not be disposed of until the black hoops were painted red. So much for native tastes and fancies.

The ordinary bale contains 50 pieces, although as many as 500 are sometimes packed together. When goods are placed in a packer's hands, the shipper gives minute directions how they shall be put up. If the packer fails on his part, and any damages arise, he is liable for the same. Of course there are various styles of packing, and cheap goods are often imperfectly packed. It is claimed, however, by old and experienced houses, that cheap packing is always, as a rule, the dearest, owing to the dangers of damage through damp and handling. Hydraulic presses are generally used in packing, and the following is the *modus operandi*, as a rule: First, the necessary iron hoops are laid on the bed of the press, commonly 5 in number, and on these the coverings for the goods are placed in their order. The tarpaulin is cut large enough to cover the top of the bale and fold down 6 in. or more all around. The goods are laid on the coverings, and a duplicate covering is laid on top, corresponding to that on the bottom, when the bale is pressed. A piece of tarpaulin is then wrapped around the bale, wide enough to cover the portion from the top and bottom nicely, and then the ends and sides of the covering are neatly folded. The outside wrapper is then sewn up with strong twine, the hoops are riveted, and the work is done. The latest rivet used has 2 shoulders on it, and when placed in the slot cut through the hoop and turned half round it holds fast. When the pressure is taken off the bale, the hoops are so tight that the rivets cannot well be moved.

The following methods of packing may be considered representative:—

(*a*) Best. The goods are wrapped in (1) white paper, (2) grey paper, (3) linen oil-cloth, (4) brown paper, (5) patent black tar cloth, 20-porter linen, (6) brown paper, (7) outside canvas, 18-porter linen, (8) iron bands.

(*b*) Second. The goods are wrapped in (1) double grey paper, (2) jute canvas, 16-porter, (3) best brown tar cloth, 20-porter linen, (4) brown paper, (5) outside canvas, 18-porter linen, (6) iron hoops.

(*c*) Common. The goods are wrapped in (1) white paper, (2) double paper, (3) common brown or tar cloth, 16-porter jute, (4) brown paper, (5) outside canvas, 18-porter jute, (6) 5 iron hoops 1¼ in. wide.

(*d*) Commonest, for India and China goods. The goods are wrapped in (1) double grey paper, (2) common asphalt tar cloth, 14-porter jute, (3) brown paper, (4) outside canvas, 18-porter jute, (5) 5 iron hoops 1¼ in. wide.

(*e*) Recent, for India and China goods. The goods are wrapped in (1) double brown paper, (2) glazed brown paper, (3) tarpaulin, (4) common brown paper, (5) outside canvas, 18-porter jute, (6) 5 iron hoops.

These examples will furnish full details of the methods, and in large part the materials, in use here in packing goods for the different markets of the world, so far as the coverings are concerned. Some packers use white

paper next to the cloth, while others use "unbleached" paper, claiming that it is purer and less liable to injure the goods. Style (*e*) of packing has been used by a large firm in Manchester for 2 years past, without a single complaint from purchasers.

For Africa.—Goods for Africa are, in large part, cased in wood and tin. They are generally packed in small cases so that they may be easily transported on camels. The cases are 12–14 in. deep, and the width and length depend upon the size of the cloth. If the goods are heavy, what is known as German-hoop cases are used; if light goods, plain hoops are provided. A layer of ordinary brown paper is placed next to the cloth, so as to prevent the tin from soiling or rubbing it. Fine pieces are generally packed in brown-paper packages, and these are first pressed before they are placed in the tin- or zinc-lined case, so as to form as solid a package as possible. Where goods are packed in bales for Africa, much the same covering is used as in the examples already given. The cheap goods are generally packed in bales to save expense.

For India.—Small bales are the rule in this great trade. Double wrappers are generally used, and for the interior 4-fold wrappers are necessary to protect the goods from the rough usage of long overland conveyance. The paper and other wrappers are similar to the examples given.

For Australia.—For this market the largest buyers have their goods packed in zinc-lined cases. The zinc finds a ready market for roofing purposes. The covering for the goods is similar to the packing for the African trade.

For Europe.—The goods are mostly packed in large bales for these markets, about 20 cwt. each. Spain will not have small bales. All these goods are packed in single wrapper. Jute wrapper is used, but single wrapper, though rather dearer, is much the best. The difference in the cost of the two wrappers, for a bale requiring 4½ yd., is about 6*d*.

For Gibraltar.—The bales landed at this point have a covering of wood ½ in. thick on the top and bottom of each bale, to shield it, as packages receive rough handling at this port. It has been found that this protection of wood adds to the security of the goods, and also meets the wishes of merchants who purchase them.

For River Plate.—Specially small packages are made up for this trade, as they are transported hundreds of miles on mules, and these average about 80 lb. in weight. They are some 3 ft. long, 2½ ft. wide, and 8 in. thick; 3 iron hoops are used, and the covering is similar to (*d*) heretofore given; 2 of these packages are carried by each mule, one on each side.

Wrapper or Canvas and Tarpaulin. Wrapper is of different qualities, and is described as 6, 8, 10, 12, 14, 16, 18 and 20 porter wrapper. The term "porter" indicates the number of threads to the inch; 16-porter wrapper meaning 16 threads to the inch, and so on. The larger the numbers, the closer and finer it is, 16 being the popular wrapper in general use. The wrapper is 32, 36, 40, 45, 50, 60, and 72 in. wide, and has to be selected according to the width of the goods to be packed and the intended size of the bale. Very little of 60 and 72 is now used, but the packer must always keep these widths in stock. The tarpaulin need not be above 50 in., which is the maximum. If it is too narrow to cover a bale, a slit can be cut to cover the same. There are 3 widths for tarpaulin, viz., 36, 40, and 50 in. Both wrapper and tarpaulin should be kept on rollers, where they keep softer, and the latter more pliable.

There are various preparations used in the production of tarpaulin, and almost every manufacturer has his own special mixture. Among the many named are the following: 5 parts Stockholm tar pitch melted with 4 of rosin and 1 of Stockholm tar; 48 parts Stockholm tar pitch, 10 Stockholm tar, 32 rosin, and 1 tallow.

Special attention must be called to

the necessity of having thick packing paper, in double sheets, placed between the tarpaulin and cotton goods, where the tarpaulin had been made with the pitch of cotton-seed and other oils, as damage to the goods would take place unless this precaution was observed.

The cost of tarpaulin in Manchester is as follows: 36 in. wide, 3¾*d.* per yd.; 40 in. wide, 4½*d.* per yd.

Iron Hoops.—The best hoops cost 9*s.* to 9*s.* 6*d.* a cwt., cut to the desired length, and painted such colours as may be desired.

Paper.—Turner's patent packing is much used here as a substitute for paper. It is strong, and answers its purpose very well. The prices are as follows: 22½ in. wide, 1⅝*d.* per yd.; 28 in. wide, 1⅞*d.* per yd.

Twine.—The twine used in sewing up the bales should be finished in tallow, as this is much the best. Jute stitching-twine is generally used here, but cotton twine is stronger and better. It never gets hard, and is more pliable than jute. A good twine costs here 10*s.* 6*d.* per doz.

German Packing.—For the packing of woven goods in Germany the following precautions are taken. The fabric is first folded on thin wooden board, then wrapped in white paper, then again in blue paper, then labelled, and put in pine cases, the corners of which are sealed with pitch so as to render them water-tight. Tin was formerly used for this purpose, but pitch has proved cheaper and equally serviceable.

Common braids are generally wound up in pieces, each containing 36 yd., wrapped in yellow or brown paper. A small piece as sample is placed on the outside of each package and the trade-mark pasted on. Four packages, containing 144 yd.—a gross—are placed in a carton, and then the whole tightly boxed up, so as to prevent movement during the transport. Finer qualities of braids, such as mohair, and genappe are commonly reeled on slats or pasteboard, covered with blue or red glossy paper; a fine tissue-paper, generally a white one, with the trade-mark pasted on it, is wrapped around the braid, so as to keep it from rubbing, and giving it a fine appearance at the same time. These braids are likewise placed in elegant cartons, lined with yellow English leather, also by the gross, and then boxed up.

Common trimmings, such as rick-racks, etc., are commonly put up in bunches containing 12 yd. each, simply tied with a red cord, the trade-mark adjusted in the centre of the bunch, and the whole is wrapped up by the dozen in blue paper. Common bindings are put up in a similar manner, but are uniformly packed in gaudy cartons. Finer trimmings and bindings undergo the same process in packing as the finer braids. Common bands are reeled by 500 yd. on bobbin, and yarn is put up in skeins by the pound. These goods, when consigned to parties within the "Zollverein," and to neighbouring countries, such as France, Belgium, Netherlands, Switzerland, and Austria, are generally packed in simple wooden cases. Goods consigned to remoter countries, such as Italy, Spain, Russia, and Turkey, are frequently wrapped up in strong varnish paper; and, when shipped to the United States, are generally enclosed in oil-cloth so as to keep off dampness, and then put in wooden cases. Similar shipments to Mexico or the South American States are mostly encased in tin boxes, and, after being soldered, these are placed in wooden boxes. It may, however, be remarked that, as a rule, German exporters do not excel in packing, and are rather careless and deficient in this important trade appliance.

French Packing.—Goods for long voyages are usually packed in this manner: A strong box is made from 1-in. boards, being in length and breadth inside about the same as the length of the goods to be packed, and of any required height. The box is then lined with sheets of tin, cut so as to fit the box closely. The seams of the tin are then carefully soldered on the bottom

and sides so as to be water-tight, after which a lining of coarse, cheap cloth, or other substance, is placed inside in order to keep the goods from being damaged by rubbing or chafing. The goods are then packed in firmly, each piece being wrapped in paper, and each alternate layer being placed crosswise, of the other until the box is full, when a like protection of cloth or other lining is placed over the top of the goods. Then the tin cover is put on and carefully soldered at the seams where the tin is joined, making the whole perfectly water-tight. The top of the wooden box is then put on, and the goods are ready for shipment. It is claimed that goods packed in this manner may be shipped to the most distant countries without danger of being in the least damaged by shifting, chafing, or from the elements. In fact, it would seem quite impossible for the goods to receive damage, even if they were to encounter rough handling or be quite immersed in water by reason of boisterous weather at sea. As the tin lining of the box is available but for the one shipment, it is only necessary to use light, cheap tin. The tin lining may be properly designated as a tin box to be placed within a closely-fitting wooden box or case in which to pack goods for shipment, and for the sake of convenience may be constructed separately so as to be ready for use when wanted, and placed within the wooden box or case when the goods are required to be packed.

For shorter and less dangerous voyages, goods are usually packed in square-shaped, coarse sacks, around which is placed wheat, rye, or oat straw, and around this is placed still another sack of strong material. Frequently the outer protection in this mode of packing is simply an open box, made from strips of board 3 or 4 in. wide and about the same distance apart, and being fastened to a square frame at either end. These boxes, or more properly crates, are rough and cheaply though strongly made, and are used for the purpose of keeping the straw in place around the sack and the goods from being damaged. The sacks used in this manner of shipping are returned by the consignee to the shippers, and may be used until worn out. This process of packing is used only in inland transportation, and appears to be convenient, and to have the advantage of a great saving in wood over the large and cumbrous dry-goods boxes one is accustomed to see in America.

Protecting Carboys.—A very simple but ingenious contrivance—it is so simple that the wonder is the idea has never occurred to anyone before—for protecting the upper portion of carboys when packed in hampers, is called the "Marple Carboy Protector." The main object of this appliance is the protection from breakage of carboys when shipped abroad. It is well known in the chemical trade that all sorts of devices are made use of to prevent breakage of bottles containing acids and expensive solutions when consigned on long voyages. Some manufacturers even go to the trouble and expense of placing the full carboy (hamper and all), in small empty casks, packing them well with straw, making up the lid, but leaving handle holes at the sides of the cask. Others cover the top of the hamper with a circular piece of timber with a hole in the centre to fit round the neck of the bottle, and then fasten it down to the hamper with baling rope. Some years ago we saw a patent package consisting of a stumpy kind of barrel in which the bottle was permanently fixed, embedded in a kind of cement up to the neck, with a lid and handles. This was very good in its way, but it will be easily understood that expense alone prevented its general adoption.

The "Protector," as will be seen from Figs. 84, 85, 86, is simply a loose lid made to fit the hampers, and consists of two metal rings, the smaller and inner one intended to fit round the neck of the bottle, after being well packed with straw or hay on the top,

whilst the larger or outer ring fits just inside the top hoop of the hamper, to which it will be lashed with twine or wire. The two rings are braced together with extra-strong narrow hoop-iron, and the whole is then varnished like the "Marple" hampers.

no more, of any particular chemical, there is no reason why the "Protector" should not prove as great a boon for the home trade as it undoubtedly will for the foreign trade as regards chemicals consigned in carboys. ('Chem. Trades Jour.')

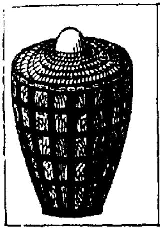


FIG. 84.

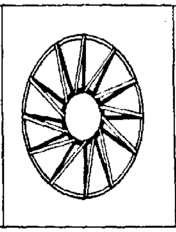


FIG. 85.

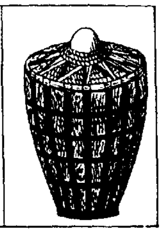


FIG. 86.

This appliance ensures almost absolute immunity from breakage, and its cost is trifling as compared with other contrivances hitherto in vogue. The only part of the bottle that is exposed is the corked portion of the neck, and as the "Marple" hampers are shaped so as to stow easily in tiers, the slight projection of the cork above the level of the "Protector" is of no material consequence. We may add that as evidencing the practical value of the "Protector," we saw a cargo of vitriol in bottles being stowed in a narrow canal boat—perhaps the most awkward kind of "vessel" to stow carboys in—and with the "Protector" affixed, the carboys were being stowed away in tiers four or five deep like so many drums, and the workmen were standing and walking about on the tops of the bottles as though they were on terra firma.

The only drawback we can see to the general use of the "Protector" is that when affixed it is not easy to see when the bottle is getting full. This will militate against its use, say for the muriatic acid trade, where the bottles are usually filled by hose quickly, but where bottles are filled by funnel, and a recognised *rule* adhered to of filling every bottle with a given weight, and

Acid.—It has been shown that concentrated sulphuric acid of 66° B., brought into contact with straw, wood, and other organic stuffs at ordinary temperature, can develop volatile organic acids and sulphurous acid in considerable quantity. This sufficiently explains the destruction of iron parts of vessels, etc., not in actual contact with escaping acid, and indicates that sleeping in enclosed spaces in which concentrated sulphuric acid is being conveyed can only be warranted where ventilation is very good.

Eggs.—(1) Buy boxes from the grocer at 1*s.* a dozen and pack in meadow hay. Procure a suitable size box, fill with hay, press down tightly, then make holes with two fingers and thumb of the right hand, and place the eggs in position with the left hand. Dozens can be packed in this way in a very short time. Divisional boxes, paper wrapping, cork, bran, sawdust, all fade away as soon as this simple, inexpensive, handy, and expeditious plan is adopted. Never buy boxes *from the manufacturer of boxes for sittings*; they are too careful of the wood and quality. (J. Francis Brown.)

(2) I send [illegible] London with a [illegible]

paper about 2 in. wide wrapped round each egg (corrugations inwards, of course), and a layer of hay top and bottom and between each layer of eggs, in wicker baskets (circular by preference). There is scarcely ever a single egg broken, and it is the simplest, safest and most rapid packing of the many modes I have tried and seen. The wrappers are retained in place simply by juxtaposition; eggs large ends downwards. The paper is that commonly used for wrapping medicine bottles for post. (Francis Bacon.)

(3) The eggs may be packed in a rectangular hamper, 15 in. by 7 in. by 5 in., each egg wrapped first in fine shavings and then in a piece of coarse paper wrapping, which is folded on the breadth, and not the lengthways, of the eggs. The bottom and sides of the hamper are lined with fine wood-shavings, and the eggs placed end to end in a double row on the packing, with another layer of the shavings on the top of all. The eggs cannot come to any harm; but the cost of the hamper plus the cost of the postage puts this form of package out of the question for moderately cheap eggs sent by post.

(4) My new laid eggs sent to London are packed in clean soft straw in boxes 9 in. deep, four layers to the box; the boxes contain 300, 400, and 500 each (120 to the 100); as much straw should be placed on the top of the box as will make the lid quite tight when tied down; this prevents the contents from moving in transit. The breakage in this way does not exceed 1 per cent. New laid eggs sent to the south coast towns are packed in Tully's patent boxes, cardboard divisions, thick felt between. I never have a complaint of breakage in these boxes. Pheasants', turkeys', goose and fancy fowls' eggs, are always packed in baskets, each egg wrapped in soft hay separately. These are sent to nearly all parts of the United Kingdom, France, Italy, and Belgium, and I never hear of an egg being broken. Sawdust, bran, etc., are very unsafe packing, as the contents move about, besides excluding all air, which, when packed in boxes, is very injurious to eggs intended for incubation. I always send eggs for hatching by rail. (G. Russell.)

(5) The box may be of the ordinary 12-division type, but a layer of corrugated paper is placed top and bottom, and a small roll of the same material in each division to hold and protect the eggs. The principle appears to be right and very simple.

(6) My experience is that those eggs travel best that are first wrapped in paper, then packed tightly in sawdust in divided wooden boxes.

Oat-chaff and bran I dislike; hay is good, but I think quite unnecessary. In large towns all these have to be purchased, whereas sawdust, as a rule, costs nothing, and is, in my opinion, better than anything else into the bargain. I generally place a few half-sheets of newspaper on the top of the sawdust to prevent any working out during the journey. The lids of the boxes should of course never be nailed down; they should be either screwed or tied securely with strong string.

There is generally a slight difficulty in unpacking the eggs, as the sawdust when fine and well pressed, sets firmly round each egg. This is overcome by putting a thick layer of sawdust on a table, then turning the box upside down, sliding the lid off, and drawing out the divisions, and with them the eggs *en masse*.

Suggested precautions:—

(*a*) Always rest eggs 24 hours after a journey.

(*b*) Always print or write legibly "Eggs for Sitting" on each box.

(*c*) Always make a string or wire handle to each box.

(*d*) Never nail an egg-box. (R. de Courcy Peele.)

(7) At all times I have used (in preference to hay or any other packing material) flax dust, which is more elastic than anything else I can obtain, at the same time being wonderfully light-weighing. This dust may be

bought in quantity where the flax (Dew Ripe) is grown; but I believe it is chiefly confined to the south-west counties of England.

(9) The box is a light wooden one, divided into 12 compartments for eggs. The partitions come full out to the sides of the box, giving great strength. The eggs are very tightly packed in hay in each division, with a layer of hay top and bottom, and on the top of that a layer of chaff. So protected with an elastic cushion like hay, it must be exceedingly rare for an egg to be broken.

Packing Smoked Hams and Bacon for Export.—These goods must be as dry as possible before being put in their canvas covers. A drying room is best to effect this, no heat being required, but a plentiful current of air. Flour, sawdust and similar materials, sprinkled on the goods, have been tried for drying but are not effective. Flour in particular is bad as being liable to decay. A good preservative is a weak solution of creosote in water. It is not harmful, being, in fact, a substance that is produced naturally in the smoking. A solution of borax and water is also a good preservative and does not affect the quality of the meat in any way. If either solution is used the goods must be dried before being wrapped. The canvas wrappers can be soaked in borax and water, but must be dried before use; it is a good plan if the meat is expected to sweat a little. All packing cases should be strong and some effort be made to get them water-tight, as water or heavy water vapour may be in the vessel's hold.

Packing Honey Sections.—Honey sections when packed in a box, however strong the box may be, are often damaged by shock due to the box being dropped. The following plan, though appearing to give more trouble in packing really takes little extra time, and old or light or rough boxes can be used. The idea is to pack the sections in a simple made crate before putting them in the box. The crate can be made of moderately light stuff, according to the number of sections. If twelve sections are to be sent, arrange these compactly on edge (as they stand in the hive), then measure and cut lengths of say 1½ in. by ½ in. stuff to form a crate that will fit the sections tightly. Nail the parts together to form the crate, leaving one end open; put the sections in, then nail up the open end. Now cover the whole crate with newspaper, and pack it in a box a little larger than the crate, packing the space around the crate with shavings, straw, or any springy material. For greater weights, the box (in which the crate goes) can have a number of spiral springs, strong but short, nailed around its inner surfaces, these being better in withstanding shock than shavings or straw, but this could only be done with boxes that are charged for and returned.

Making Packing-Paper and Cloth Waterproof (*see also* WATERPROOFING).—Either of these materials can be treated with a preparation of resin, wood tar, creosote and pitch. The mixture is made hot in a suitable pan (preferably by steam heat), and the cloth carried through it by a submerged roller; then as the cloth comes out it is scraped by a pair of knives to remove excess material. The treated cloth then goes over rollers placed well apart, and, when cool, it will be found hard enough to roll up without sticking. Paper is treated by coating it on one side only, either painting it with a brush, or causing it to be passed over and pressed on a flannel-covered roller, which is saturated with the hot tarry preparation.

Another method is that of converting soap to an insoluble substance by the addition of alum. Pass the cloth or paper through a warm solution of soap and water, 10 lb. of soap to 10 gal. of water, and afterwards through a warm solution of alum and water, 10 lb. of alum to 10 gal. of water. As the cloth or paper comes from this last bath pass it through the rollers of a wringer and let it dry. The soap will

be found insoluble and the material waterproof.

Storing Ice.—The storage of ice in large quantities is a matter demanding some skill and experience in the construction of the "house." The following directions are given by various authorities.

(1) Build a round brick well, with a small grating for drain at bottom for the escape of water from melted ice. Cover the bottom with a thick layer of good wheat straw. Pack the ice in layers of ice and straw. Fix a wooden cover to the well.

(2) Fire-brick, from its feeble conducting power, is the best material to line an ice-house with. The house is generally made circular, and larger at the top than at the bottom, where a drain should be provided to run off any water that may accumulate. As small a surface of ice as possible should be exposed to the atmosphere, therefore each piece of ice should be dipped in water before stowing away, which, by the subsequent freezing of the pieces into one mass, will remain unmelted for a long time.

(3) Make a frame-house the requisite size, with its floor at least the thickness of the bottom scantling from the ground, thus leaving space for drainage and a roof to shed off the water. The boards of the wall should be closely joined to exclude air. Then build up the blocks of ice, cut in the coldest weather, as solid as possible, leaving 6 in. all round between them and the board walls; fill up all interstices between the blocks with broken ice, and in a very cold day or night pour water over the whole, so that it may freeze into a solid block; shut it up till wanted, only leaving a few small holes for ventilation under the roof, which should be 6 in. above the top of the ice. It is not dry heat or sunshine that is the worst enemy of ice, but water and damp air. If all the drainage is carried promptly off below, and the damp vapour generated by the ice is allowed to escape above, the column of cold air between the sides of the close ice-house and the cube of ice will protect it much better than it is protected in underground ice-houses, which can neither be drained nor ventilated; sawdust also will get damp, in which case it is much worse than nothing.

(4) An improved sort of ice-house, recommended by Bailey, gardener at Nuneham Park, Oxford, is shown in plan and section in Fig. 87, where the dotted line indicates the ground level. The well or receptacle for the

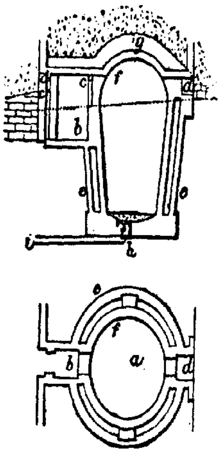


FIG. 87.

ice *a* is 10 ft. 6 in. wide at the base, and 3 ft. wider near the top; the walls are hollow, the outer portion being built of dry rough stone, and the inner wall and dome *f* of brick. The outer wall *e* might be replaced by a puddling of clay, carried up as the work proceeds. Over the top is a mound of clay and soil *g*, planted with shrubs to keep the surface cool in summer. The drain *i* carries off the water formed by the melted ice, and is provided with a trap *h* to prevent the ingress of air through the drain. There is a porch or lobby *b* provided

with outer and inner doors *c*; and apertures at *d*, to get rid of the condensed moisture, which, if not removed, would waste the ice. These ventilating doors should be opened every night, and closed again early in the morning. The most important conditions to be secured are dryness of the soil and enclosed atmosphere, compactness in the body of ice, which should be broken fine and closely rammed, and exclusion as far as possible of air. ('Gard. Mag. Bot.')

(5) A very cheap way of storing ice has been described by Pearson, of Kinlet. The ice-stack is made on sloping ground close to the pond whence the ice is derived. The ice is beaten small, well rammed, and gradually worked up into a cone or mound 15 ft. high, with a base of 27 ft., and protected by a compact covering of fern 3 ft. thick. A dry situation and sloping surface are essential with this plan, and a small ditch should surround the heap, to carry rapidly away any water that may come from melted ice or other sources.

(6) The following is an economical method of making small ice-houses indoors: Dig a hole in a cool cellar, and make it of a size corresponding to the quantity of ice to be kept. At the bottom of this hole dig another of smaller diameter, the edge of which goes down with a gentle slope. This kind of small pit, the depth of which should be greater in proportion as the soil is less absorbent, must be filled with pebbles and sand. The whole circumference of the large hole is to be fitted up with planks, kept up along the sides with hoops, to prevent the earth from falling in. Then the bottom and all the circumference of this sort of reservoir must be lined with rye straw, placed upright with the ear downwards, and kept up along the planks by a sufficient number of wooden hoops. The ice is to be heaped up in this ice-house, which must be covered over with a great quantity of hay and packing cloth, on which should be placed a wooden cover and some light straw. ('Les Mondes.')

(7) In preference to one or more large houses, Maclean makes choice of several small ones—each of them capable of holding, say, about 20 tons—because he finds that, an ice-house once opened, its contents, exposed to the atmosphere, are more liable to waste than the ice in one which has not been opened. The advantage of adopting the smaller houses will thus at once be seen; the opening of one exposes but a small quantity of ice at a time. Again, these houses can be rapidly filled, and should one, through any cause, fail to serve its purpose, there are others to fall back upon. Having selected a peat-moss of the required depth, convenient to a road, and near the margin of a small sheltered lake, he marks out the ground to the dimensions shown on Figs. 88, 89, 90, for

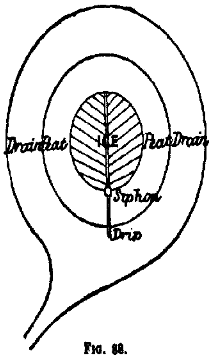


FIG. 88.

the interior of the house; the divots removed from the surface are placed in a circle round the edge of this space so as to strengthen and protect it during operations. Six men in a few hours can make the necessary excavations; two are employed clearing out the space required for the storing of the ice; one to cart; one to assist in filling the cart from the *débris*, and two are employed in cutting the drains;

a seventh man is simultaneously engaged in preparing the roof. The space intended for the ice being completed, the whole of the men, except the one preparing the roof, join in making the drain. By the time the drain is half finished the supports for the roof are put up. These are made of rough pieces of oak, and rest on barrel staves placed at the required intervals across the top of and at right angles to the wall. The spaces between the couplings are filled up with hazel or oak branches about 2 in. thick; a layer of divots, heather side inwards, is now put on; over that is laid a coating of the best and softest moss taken from the drain and tramped into a solid mass all over the roof to a uniform thickness of 15 in. After this, another layer of divots is put on, heather side out, and the whole is covered with straw or heather-thatch to the thickness of 2 in., and secured with heather-rope or coir in the usual way. The apex is protected from destruction by birds by covering it with a piece of old tarpaulin to the breadth of 15 in. The drains are dug 1 ft. below the level of the floor of the house. A hole is cut in the north side of the house to admit of a siphon being placed in it. Small drains, as shown in Fig. 88, are cut, and the siphon—which Maclean has found to answer well in the peat, and which is made of india-rubber tubing 1-1½ in. diameter, and lashed to a bit of iron bent to shape and served over with marlin—is placed. It has a bell-shaped mouthpiece made of wood or metal, with a rose covered over with a small wooden-perforated box to protect it from injury. If, by any chance, it is noticed that no drainage is coming from the house, or that the water is exhausted by evaporation, it is well to attach a small piece of leather over the nozzle of the siphon, which, when the wind blows against it, acts as a valve. A few branches placed in the bottom will keep the drains clean, and the filling of the house may at once be proceeded with. The ice should always be broken up into as small pieces as possible, well packed, and salted with snow. When the house is filled to about 1 ft. above the level of the walls, pack the remaining space with sawdust.

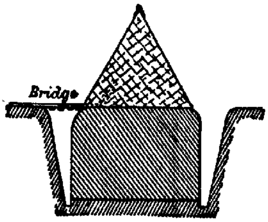


FIG. 89.

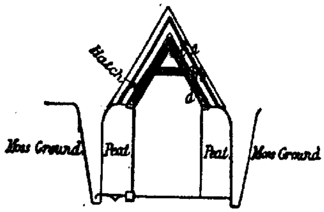


FIG. 90.

As there are many places where peat cannot always conveniently be found, Maclean would, as the next best means of preserving ice, recommend it to be stored in a house constructed on the plan shown in Figs. 91, 92: Drive pieces of split larch of the required height into the ground, so as to enclose a sufficiently large space, and place them as close to one another as possible, any rough edges

being previously cut off. Tie them inside and outside by strong rafters of the same material in a horizontal position—3 will suffice in ordinary cases; line the inside of the structure with rough sarking boards, filling up the crevices with sawdust well rammed in courses corresponding to the depth of the sarking boards all along to and underneath the baulks; thatch in the usual way with turf and straw or

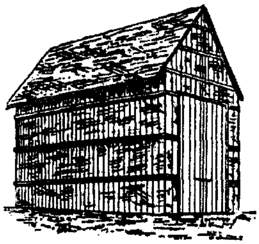


FIG. 91.

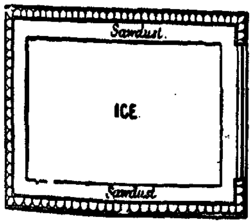


FIG. 92.

heather; put a coating of coal-tar outside the sides of the house, and give the floor a gradual slope towards the door; cut a drain round the outside to carry away the surface water and any waste that may take place. A space of 1 ft. to be packed with sawdust should be left between the ice and the wall, and filled up gradually as the ice is being stored. The space immediately inside the door should be carefully and tightly packed with sawdust: the small door made in the larger one admits of this being easily done. A house of this kind costs between 7*l.* and 8*l.* The letters on the roof indicate as follows: *a*, thatch; *b*, turf; *c*, tramped peat; *d*, rough rafters.

(8) The old-fashioned plan of storing ice under ground was assuredly a good one, but had the disadvantages of occasionally being impracticable, from the character of the subsoil, and always expensive.

An ice-house, to be thoroughly efficient, need not be under ground. The chief requirements of such storage are that it be formed of non-conducting materials, so far as heat is concerned, and so constructed as to give easy access, and drainage, without unduly admitting the external air. Added to these, and the better to ensure an extended sphere of usefulness, low first cost must be mentioned.

These indispensables to the modern ice-house, in Ross's opinion, are happily not far to seek. In wood we have the first requirement admirably met, while its adaptability and cost leave nothing to be desired; and, if care be exercised in the selection of the kind of wood used, and in its subsequent preservation by an occasional coat of paint, it will prove to be by no means the ephemeral material many suppose. The sole remaining difficulty is the design of the structure. So far as surroundings are concerned, a shaded situation is preferable, but not indispensable; and as for the external elevation, it can be modified to meet the taste and purse of the owner. By adopting any of the many modifications of the circular form, the ventilation is the better assured, while the cost is not in any degree enhanced.

The entire floor, extending at least 1 ft. beyond the exterior of the walls, should be of thoroughly laid concrete, not less than 1 ft. above the surrounding level, attention being given to have foothold for the wall-posts and slope from the centre for drainage. By this form of floor we guard against

excessive terrestrial radiation and vermin.

The walls can be raised with any required number of angles, and the structure may range from a pentagon upwards. They must be double, with an interspace of 18 in. at least, and of sound pitch pine—the interspace to be filled with the most efficient and cheapest non-conductor we have, viz. sawdust. Two doors are needful, one in each wall, and they must fit pretty tightly. The roof must be lined internally on the couples, and the interspace filled with sawdust as before. Felt is preferable as a roof covering, and the apex of the roof must be of the "Lutther" class of ventilator. The whole exterior to have 3 coats of best silicon white paint. For drainage, surface gutters in the concrete, radiating from the centre, and having trapped termini debouching at the underside of the concrete.

The house finished, it has to be filled. This is best done by pounding down the ice, from whatever source derived, packing it closely in, and ramming it well together as it accumulates.

Cold Storage Room.—A cold store should be built in the shade, and needless to add, everything favourable to its keeping cool must be considered. Either brickwork or timber may be used, but timber is cheapest, especially as cold stores are often more or less temporary buildings. If possible start by excavating some of the ground out, for if the floor is only a few inches below the ground outside, it is better than being above this level. A stone or cement floor is better than wood, being cleaner and less liable to injury by damp. In building with wood, fix the uprights as usual, then cover the outside and inside with boards so that there is a 4-in. to 6-in. space between. Fill this space with sawdust, though silicate cotton is better in resisting the passage of heat, and is a sterile material and vermin proof. If possible, cover the whole of the outside with roofing felt, and whitewash it. A thatched roof is best in preventing heat passing through. If a low temperature is required, one or more blocks of ice can be kept in the store, but for a uniform temperature the ice should be put up near the ceiling rather than near the floor, as cooled air always falls and does not ascend. The following are chemical cooling agents, sufficient to lower the temperature of the air to below freezing-point if required. 1 lb. of sal ammoniac is intimately mixed with 2 lb. powdered saltpetre, then is added and mixed an equal bulk of Scotch soda. On these dry ingredients is poured half the bulk of cold water. Nitrate of ammonia dissolved in rather less than its own weight of water is a powerful cooling and freezing agent, but is expensive. It can be recovered, however, by evaporating off the water, and is then fit for use again. Another mixture is sulphate of soda (Glauber's salt), on which is poured muriatic acid, say 2 lb. of acid to 3 lb. of salt. This is fairly cheap, but has a bad odour unless in a carefully covered vessel.

Fruit and Seed-Potato Store. The following brief description may be made to apply to a general vegetable store, only that in showing a number of tray or lattice shelves, it is supposed that the fruit will be spread out in single layers. Ordinarily vegetables stored for daily use are, more or less, heaped up and require to be spread out and sorted over occasionally, which would not be convenient in a store closely shelved as Fig. 93 shows. The width of this house would be 10 ft. and any length required. The excavation should be 1 ft. 6 in. to 2 ft., according to whether the soil is dry or not (free of high subsoil water in wet weather). The wall would be 4½ in. brickwork, say 4 ft. to 5 ft. high above outside ground level. The roof is thatched 15 in. to 18 in. thick on rafters or rough poles. Outside the walls are banked up with earth as shown, this being the earth from the excavation, and the thatch comes well over this. Ventilation can be provided by a small opening beneath the door and another

at a high point at the opposite end of the building, but it may be noted that fruit and vegetables do not require ventilation so much as a uniform moderate temperature. Too much ventilation would cause injury by frost in severe weather. The door should be double, or else well lined with felt, and any window provided should also be double. The floor

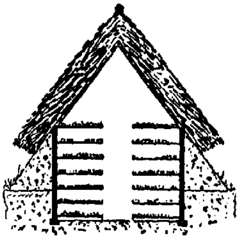


FIG. 93.

should be earth, and if slightly damp will do more good than harm. The chief use of ventilation is to carry off the rather abundant moisture and odour that fruit gives off for about two weeks after it is picked. After this the fruit ceases to perspire freely, and ventilation is only needed a little now and again. The shelves, for single layers of fruit, need only be 9 in. to 10 in. apart, and are formed of stout lathes or battens any width up to about 3 in., with a 1 in. space between each. A 2 in. ledge in front prevents fruit rolling off, and some gardeners like to have a very thin layer of straw on the shelves. Occasionally, too, gardeners store the apples on these shelves two deep, but not if they have space to avoid this. The window should only be large enough to just give the light required for handling the fruit, for darkness is favourable to keeping fruit. On this account the window may have a blind or piece of sacking over it to be raised as required.

PAINTS AND PAINTING

FOR COMMERCIAL AND ARTISTIC PURPOSES.

(*See also* ENAMELLING, JAPANS AND JAPANNING, LACQUERS AND LACQUERING, *and* STAINS AND STAINING.

Preparation of Materials.—For those who prepare and mix their pigments from the dry state the following opening hints will be of use. In dealing with the rough material, it is always a first duty to make a careful inspection for the purpose of removing all hard and impure lumps, also stones, nails, etc., before the materials go to the rollers. The rollers are made of hard metal, usually about 2 ft. long and fluted. For large requirements power, gas or steam, is made use of, but for smaller purposes there are no objections to a hand-power machine. This rolling machine is for crushing purposes only, the grinding process being quite separate.

When a machine is not available a hand roller worked on a slab of hard wood can be made to suffice.

From the crushing rollers the materials go to the drying pan. This may be a large shallow pan, heated by steam, while for small purposes many painters use a pan or tin placed on the hot plate of the kitchen range at moderate heat. The materials must be dry and be allowed to cool, after which the sifting is done. Commonly, the stuff is first passed through a cane sieve, then through one of horse hair, after which the different colours can be put together in their suitable proportions for mixing. Here again a mechanical mixing machine may be used with best results, though hand mixing must be resorted to when a machine is not available. It is as well to have separate pans or machines for mixing light and dark colours.

The final process of grinding the mixed dry colour in oil is usually done in a machine or mill, though for small

quantities the oil may be added in a mixing pan and the mixture then finished by rubbing smooth in a pestle and mortar. For grinding white-lead and all heavy colours such as reds, browns, and yellows, granite or other stone may be used, but for fine colours a steel hand-mill is best. It is important that this latter mill be kept clean.

In working any form of grinding-rollers, great care must be taken to clean them thoroughly immediately after use. If the paint be allowed to dry upon the surface of the rollers, it is difficult of removal, and interferes with the perfect action of the machine. Should the working parts become clogged with solidified oil, a strong solution of caustic soda or potash will remove it. By means of the same solutions, porcelain rollers may be kept quite white, even if used for mixing coloured paints. Although the colour of most pigments is improved by grinding them finely in oil, there are some which suffer in intensity, when their size of grain is reduced. Chrome red, for instance, owes its deep colour to the crystals of which it is composed, and when these are reduced to extremely fine fragments, the colour is considerably modified.

Workpeople, whether mixing or using paint, should be careful so as to avoid the poisoning effects of some of the pigments. In mixing many of the dry colours, particularly greens, a cloth should be tied over the mouth and nose. At all times cleanliness of the hands, not forgetting the finger-nails, is important. A blouse and cap should be worn. The hands should be washed before meals and no meals be taken in the workshop. Any cuts or injury to the skin should be well bathed and carefully bound up. Milk is a good drink to take, being a corrective to lead poisoning. Effervescing drinks, as they contain so much carbonic acid gas, should be avoided as this gas can combine with some kinds of powdered pigments which would otherwise be less harmful or innocuous. Vinegar and acids are best avoided. All paint shops should be thoroughly well ventilated.

Linseed-Oil.—This is used in two forms, viz. raw and boiled. The raw oil is chiefly used with white-lead colours, while boiled oil is confined more to dark colours such as reds, browns, chocolate, black, dark blues, and greens. Boiled oil with white-lead is apt to cause a yellowness and general ill effect. The boiled oil is the better vehicle of the two and should be used, when possible, for outside work, but the raw oil gives the finest and most brilliant finish for indoor work. Many painters exercise their discretion and use the two oils mixed in proportions they think best. To boil linseed-oil, to each gallon of raw oil add 6 oz. of litharge and 3 oz. of red-lead. Heat for about 2 hours. Run off the clear oil and it will be ready for use when quite cold, say 12 hours. Although spoken of as "boiled oil," the oil does not undergo actual boiling. The temperature at which it boils is over 600° F., whereas there is no advantage in heating the oil higher than 350° F.; the drying properties of the oil are not increased by heating beyond this point, while its colour is considerably darkened.

For the finer qualities of boiled oils, it is essential that the raw oil should have been stored for some time, so that it may be free from mucilage. This mucilage is the chief source of the dark colour of some boiled oils; when heated, it forms a brown substance, which is soluble in the oil itself, and extremely difficult to remove. The oxides usually added to the oil during boiling are litharge or red-lead as stated, the former being preferred on account of its lower price. About 2 to 5 per cent. by weight of the oxides or driers is gradually stirred into the oil after it has been slowly raised to about 300° F. The stirring should be continued until the litharge is dissolved, or it would cake on the bottom of the pan, and cause the oil to burn. Litharge may even be reduced to a cake of metallic lead when the fire is brisk.

Some pans are furnished with stirrers and gearing by which the latter can be worked by hand or steam. The material of which the pans are made is wrought or cast iron. Copper pans are sometimes used with the object of improving the colour of the oil. Little is known respecting the chemical reactions which take place during the boiling of oil. Even when the air is excluded during the process, the drying properties are greatly increased, and, if boiled long enough, the oil is converted into a solid substance. The loss of weight which ensues is dependent upon the temperature and the time during which the operation continues. It is less when the air is freely admitted than if the pan is covered with a hood. The vapours given off by the oil are of an extremely irritating character, and should be destroyed by passing through a furnace. As their mixture with air in certain proportions is explosive, this furnace should be situated at some distance, and the gases be conducted into it by an earthenware pipe.

To refine linseed-oil, let 20 gal. of oil have ½ lb. of oil of vitriol and 1½ lb. of quicklime added and stirred well. Boil for 2 hours. The oil is now set aside for several days to clear itself.

Linseed-oil may be bleached by being exposed to strong light in thin glass bottles. There are methods of treating the oil with acids to lighten its colour, but as yet they are considered injurious as impoverishing the lasting qualities of the oil and making it brittle.

Linseed-oil, to be suitable for painting, must dry well. A test which will indicate whether this be the case or not is to cover a piece of glass with a film of the raw oil, and to expose it to a temperature of about 100° F. (38° C.). The time which the film requires to solidify is a measure of the quality of the oil. If the oil has been extracted from unripe or impure seed, the surface of the test-glass will remain "tacky" or sticky for some time, and this will happen if the oil under examination has been adulterated with an animal or vegetable non-drying oil.

Until recently linseed-oil was frequently adulterated with cotton-seed-oil, extracted from the waste seeds of the cotton-plant. Where the admixture was considerable, it could easily be detected by the sharp acrid taste of the cotton-seed-oil. Now, however, means have been found for removing this disagreeable taste, and the consequence has been that cotton-seed-oil is so largely used for adulterating olive-oil, or as a substitute for it, that its price has risen above that of linseed-oil. Another adulterant which is rather difficult to detect is rosin. Oil containing this substance is thick and darker in colour than pure oil. When the proportion of rosin is considerable, its presence may be ascertained by heating a film of the oil upon a metallic plate, when the characteristic smell of burning rosin will be perceptible. When the percentage of rosin is too small for detection in this manner, a film of the oil should be spread upon glass and allowed to dry. When quite hard the film should be scraped off, and treated with cold turpentine, which will dissolve any rosin which may be present, without materially affecting the oxidised oil. The presence of rosin may also be detected by the following simple chemical test: The oil is boiled for a few minutes with a small quantity of alcohol (sp. gr. 0·9), and is allowed to stand until the alcohol becomes clear. The supernatant liquid is then poured off, and treated with an alcoholic solution of lead acetate. If the oil be pure, there will be very slight turbidity, while the presence of rosin causes a dense flocculent precipitate. Should linseed-oil be adulterated with a non-drying oil, it will remain sticky for months, when spread out in a thin film upon glass or other non-absorbent substance.

The specific gravity of linseed-oil is in some cases of value in estimating its quality; but as the variations are slight, it would be difficult to detect them in so thick a liquid by means of an ordinary hydrometer. A simple method of obtaining an approximate result is to procure a sample of oil of known good

quality, and to colour it with an aniline dye. A drop of this tinted oil will, when placed in the oil to be tested, indicate, by its sinking or swimming, the relative density of the liquid under examination. Freshly-extracted linseed-oil is unfit for making paint. It contains water and organic impurities, respecting the composition of which little is known, and which are generally termed "mucilage." By storing the oil in tanks for a long time, the water and the greater part of the impurities are precipitated, forming at the bottom of the cistern a pasty mass known as "foots."

To accelerate the purification of the oil, and to remove at least a portion of the colouring matter, various methods are in use. The action of sulphuric acid upon linseed-oil is not so favourable as upon other oils. It is, however, sometimes employed, in the proportion of 2 parts of a mixture of equal volumes of commercial sulphuric acid and water to 100 of oil. The dilute acid is poured gradually into the oil, and the mixture is violently agitated for several hours, then run into tanks, and allowed to settle. A concentrated solution of zinc chloride has been substituted for sulphuric acid in the proportion of about 1½ per cent. of the weight of the oil. When the reaction is complete, steam or warm water is admitted into the liquid to clarify it. Oil treated in this way loses a considerable proportion of the colouring matter which it originally contained. When the oil is to be used for white paint, it is sometimes bleached by exposing it to the action of light. On a large scale, this is done in shallow troughs, lined with lead and covered with glass. The lead itself appears to have some influence upon the bleaching of the oil, for the decoloration is not so rapid if the troughs be lined with zinc. For small quantities, a shallow tray of white porcelain gives very good results, the white surface increasing the photo-chemical action. It is not quite clear whether the presence of water accelerates the bleaching of oil by this method; some manufacturers consider its presence necessary, others omit it. Various salts are added to the water, the one most in use being copperas. However the oil may have been prepared, it will, if kept for a long time, deposit a sediment. At first this contains mucilage; but the sediment from old oil consists chiefly of the products of decomposition of the oil itself. Oxygen is not necessary for this decomposition; but it is increased by the action of light. Raw linseed-oil dries more slowly than boiled; but the resulting film is more brilliant and durable. Raw and boiled oils are therefore usually mixed in proportions varying according to the time which can be allowed for the paint to dry, or to the properties required of the film.

Boiled oil is the true grinding oil for colours, but there are what are known as "grinding oils" on the market, these being mixtures somewhat as follows: genuine boiled linseed-oil, 4 parts; pine-oil (brown or yellow, according to the tint of the paint), 1 to 4 parts. In some cases 1 to 2 parts of raw linseed may be added. They are none of them so good as the pure boiled linseed-oil, having less drying power and being more unsatisfactory generally. Their one quality is that they are cheaper.

Linseed-oil substitute, of which there are several, is made of ground rosin, 9 lb.; rosin oil, 1 quart; water, 1 pint; petroleum, 1½ gal.; quicklime, ½ lb.; sulphate of zinc crystals, ½ lb. The rosin is melted in the oils, the lime slaked with half the water, the crystals melted in the remainder. While the oil is hot, add the lime, then the crystal solution. Keep moderately hot, and stir until the lime is seen to be settling; then run off and allow to clear. No linseed-oil substitute, as yet known, can be recommended as approaching the qualities of the genuine oil.

Painters' Brushes.—There are various works on practical building which, in addition to an elaborate description of the materials used, also

give information of a more or less exhaustive kind as to the tools necessary to work in these materials; but few condescend to notice house-painters' brushes, probably because they are short-lived (the brushes) and form a very insignificant portion of the expense incurred in completing a building. Nevertheless, the painter's brush is as necessary to the finishing of a building, as, say, the joiner's plane, which is always fully described; indeed it is, in a sense, of more importance, for although the plane smooths the wood, a good brush is absolutely necessary to cover it with paint or varnish as a protection against the weather in this rather damp climate. A builder must therefore at some time or other purchase paint-brushes, and as it is not wise that a man should spend his money on tools he knows nothing about, the following notes made on looking through a brushmaker's trade list may enable him to avoid being the proprietor of bundles of horsehair and vegetable fibre tied on the end of sticks when good bristles fixed to proper handles are really what he intended to buy. On opening a trade catalogue of painters' brushes, one of the first to be seen is the "duster." This kind of brush was formerly made in sizes known as extra $^{8}/_{0}$ and $^{6}/_{0}$ down to $^{1}/_{0}$, the numbers continuing to 8 again without the 0. The $^{8}/_{0}$ is called a 7 in. brush, this dimension including the wood block at the bottom, the bristles being only about 6 in. long, and this remark as to the reputed size of the brush and actual length of bristle applies to all the shorter sizes. A duster is made of "grey middles" with white bristles outside; the large sizes were not long since used for dusting, and these, when worn down, were used for painting; but it must be noticed that the manufacture of a "duster" differs from that of a paint-brush in that the former has the end of each bristle turned outwards, so that the brush may cover as large a surface as possible when in use as a duster, whilst the paint-brush proper has the ends of all the bristles turned inwards, so as to hold the colour firmly and distribute it gradually over the work. Latterly the painter has elected to use for dusting a brush made on a flat stock from 4 in. to 4½ in. wide, set in small knots after the style of a hearth-brush, the bristles used being that known as "china" in most cases. This latter, called also a jamb brush, is now extensively used for dusting, instead of the old-fashioned and more expensive duster. Painters also use for dusting a brush made on the same principle, the stock being round; it is called a "round-set duster." It is manufactured in two sizes, the bristles being high-class Russian. The paint-brush proper, called in the trade a "ground brush," but which painters call a "pound brush" in error, derives its name from its being ground or rubbed on a stem after it is made; the object of this grinding is to clear the brush and soften the thin end or "flag" of the bristle, so that it will work smoothly and without leaving streaks on the painted surface. Ground brushes are made in various bindings and shapes, and of different sizes in each make for which any maker's paint-brush list may be consulted. The material used for the binding is string, copper wire, or tinned iron wire, the best being of course copper wire. The shapes of these brushes are round, flat, oval, and true egg-shaped oval, neither of these ovals being at all like the true ellipse of a conic section. The one-knot so-called "distemper brush," which is rarely used for distempering, is either form of the ground brush already described, tied on a flat handle instead of the handle being inserted in a wood block fitted to the bottom of the bunch of bristles as in the orthodox ground brush. The sizes $^{8}/_{0}$, $^{6}/_{0}$, $^{4}/_{0}$, etc., were at one time merely arbitrary terms, and they represented no particular weight or length of bristle; but some years ago the high-class manufacturers agreed to a specified weight and length of bristle as

standards for every brush, and in this way an $^{8}/_{0}$ ground brush of standard size, best make, will have 6 oz. of $5\frac{1}{2}$ in. bristle; a $^{4}/_{0}$, 5 oz. of 5 in. bristle, and so on for the other sizes. The outsides of these brushes are all white, and the middles white, grey, or yellow bristles. The one-knot ground brushes are frequently made with all black bristles, and they make a very excellent brush, quite equal for painting to the white, which shows the ignorance of those painters who reject a brush as being faulty if they find a few black bristles mixed accidentally in a white brush. Indeed, some knowing painters are quite sure all such bristles are really whalebone! The cheaper kind of paint-brushes are made with a mixture of bristle, horsehair, and Mexican fibre, encircled by a mixture of cheap white bristles and white horsehair. So that a casual examination does not reveal the actual fact that "things are not what they seem." There is a large trade done in preparing horsehair for such "faked-up" goods, and the manufacture is extensive enough to require the importation of thousands of tons of such hair every year for these, and shoe brushes. The shape of the brush is a matter of fancy; but the one-knot is greatly growing in favour every year as compared with the other makes. The true or egg-shaped oval is, unfortunately, not so sound a brush as either of the other shapes; in fact, an oval of any kind when bound tightly round has a tendency to become a circle, and if the length of the binding wire remains unaltered the bristles are held rather loosely by it.

Sash tools are made round: they vary in size from 16 down to 0, 14 being the largest size usually stocked. The shorter sizes are made of lily bristles with French outside; a good deal of German bristle is also used in the manufacture of this brush. Sash tools are made in two ways—the forked and the socket; in the former the bristles are fixed between two prongs formed by a fork-shaped handle, and in the latter, a knot of bristles is fixed into a hollow turned in the handle. The socket-made tools are slightly lower in price than the forked, owing to the fact that the maker is able to use a slightly shorter bristle, and in this way get the same bulk with less weight. Under the head of sash tools may be included specially made scene-painters' brushes and sash-cutters. The latter are square knots of bristles set in a tinned-iron band, with the edges of the bristles chisel-shaped, so as to be better fitted for its intended purpose. The best paint-brushes are always made with the same sort of bristles, the larger sizes entirely of Russian, the smaller sizes and sash tools being of Russian and German bristles. These latter bristles have to be divided and subdivided for colour and length according to the size brush required, for the bristles as imported vary very considerably in length, colour, stiffness, and quality, the due selection and blending of these for the special article required demands great skill and knowledge on the part of the workman. Bristles, as they arrive in this country, vary in length from 2 in. to 11 in., any beyond 7 in. being of little service, as they have not sufficient stiffness, and must be cut down. The Russian bristles come from the wild boar, who, cognisant of the requirements of the London market, is good enough to shed his coat twice a year. One coat is, however, superior to the other, and depends entirely on the season in which it is shed. The peasants collect the bristles in the woods where the boars feed, and when they have a quantity, the bristles are sold to dealers, who, after cleaning and partially preparing them, place the goods on the market. German bristles are derived from smaller pigs partly bred for the purpose. It is said that the German pig is hunted across the country to get him into a heat, as the bristles come away from his hide much easier when he is in this condition.

It should not be forgotten that though all bristles are hair, all hair is

not bristle, for builders are frequently deceived by seeing a brush marked "warranted all hair," which may be quite true, but some of the hair is frequently horsehair of little value in a paint-brush, as it lacks the spring of real bristle. Horsehair is not worth one-sixth what good bristle is worth, and a brush made of all horsehair would be of no use whatever for painting. Mexican fibre, a vegetable substance, is frequently used to mix with bristle;—to do so with any degree of success it is dyed to resemble it, and though in paint-brushes it is comparatively valueless, it may be used with great advantage in lime-brushes, for lime, which destroys the best bristles, does not injure fibre.

Bristles come to this country in casks: they vary much in colour, and are classed as lily, half-white, black, and grey, the latter being really an admixture of two or more of the other colours, as there is no such thing as a grey bristle. A cask may contain one or more different coloured bristles. The peculiar stiffness of a bristle is what makes it valuable in the manufacture of paint-brushes, and the stiffness depends on the country which produces the bristle, and the time of year it is gathered. The boar with the best coat is invariably found in the colder climate.

Another kind of bristle comes from France: it is completely dressed, bleached, and assorted for colours, which are nearly all white, or light grey. French bristles, being soft, are used principally for the outsides of sash tools and other articles not requiring so much stiffness as that afforded by the Russian bristle. The price of bristles depends much on colour as well as on stiffness, lily being the most expensive, black or yellow and half-white coming next. Grey, being a mixture of all the others is more plentiful, and therefore cheaper. A painter will always insist on having a white brush, or one having a white outside and grey centre, though he will, without hesitation, plunge it at once into a pot of black paint. The lily-white bristles used on the outsides of paint-brushes, although more costly than the other kinds, often have less stiffness than the insides, because all the stiff bristles have been withdrawn from the parcels for the manufacture of high-class hair-brushes. Stiff white bristles, which were formerly in great demand by shoemakers for pointing their wax threads, are now seldom used, the introduction of machinery into the boot trade having completely done away with this use for them. In the preparation of a bundle of bristles for a paint-brush great care must be taken to give it a fair amount of solidity without sacrificing its spring or the softness of the top. Lily bristles only are, as a rule, sorted for stiffness; the stiffest are always the thickest, hence they are easily sorted from the rest. Great care has to be exercised in keeping the bristles in a brush all one way, for the root of a bristle is blunt, whilst the top or working end is split and soft. A painter will often complain that his brush is adulterated with whalebone, when the fact is that an extra stiff bristle or two are turned the wrong way up, and these cause streaks along the paint. Bristles are selected for the higher class of paint brushes for their straightness, as every bristle has a certain amount of bend, the German more than the Russian. Thus careful sorting becomes necessary. A bristle is imported from China which varies in length from $2\frac{1}{2}$ in. to 6 in., but this class is so lacking in strength as to be of little use, except for adulterating the bristle in the denser kinds, and manufacturing the cheaper kinds, of brushes.

Varnish brushes of hog-hair are made with best bristles specially prepared. This preparation consists in selecting straight bristles only, and removing all with a tendency to curve. These selected bristles are cleaned and bleached, any black hairs being removed. This latter precaution is taken for the sake of appearance only. Var-

nish brushes are to be obtained in a great variety of sizes and shapes—being round, oval, flat, tied, driven, encased in tin or in copper bands. The working ends of all these are bevelled, so as to be ready for use. When a new paint brush is used in varnish it invariably comes to pieces, and when a varnish brush is put into water the same result follows. In such cases the maker is blamed, although it is customary to stamp on the handle of each that the brush must not be soaked in water. The spirit in varnish destroys the cement used in manufacturing a paint brush, while water dissolves that in the varnish brush.

Kalsomine and alabastrine brushes are made much after the style of the nailed stock brush; but they have a broad brass band and a very high-class bristle specially prepared by scouring and bleaching, both of which processes take from the efficiency of the bristle, though they add to the appearance of the brush, and also enhance its price.

A *weather-board brush* is similar to the foregoing in every way, the bristles being secured; but the kalsomine brush begins at 5½ in. or 6 in. wide, whilst the weather-board brush ends there, beginning at 3 in. These brushes are not purchased in England, though they make handy tools for paperhanging.

A *paperhanger's brush* is made like a thick-handle distemper brush, the bristles being inserted in the handle with pitch—that is, set in knots, after the style of a broom, or the set duster already described. Paperhanging brushes are made of high quality bristle, for use in paste.

A *papering brush* is that with which the paperhanger presses the pasted paper on to the walls, and smooths it over, squeezing out air-bubbles. In fact, it is used by the tradesman where the amateur would use his hand. One kind of papering brush is set after the same manner as the paperhanger's brush; in the other the knots are drawn in with wire. The stock of the first is a solid piece of wood, and that of the other has a back, which is fastened on to conceal the wire, something like a shoe or spoke brush.

Stipplers are made with high-class bristle, and, owing to the cost of preparing it, the stippler is an expensive brush. In the preparation of the bristle it loses 25 per cent. in weight, and the labour on the brush is also costly in proportion to that on other brushes. The object sought, in making a brush of this kind, is to obtain a perfectly uniform flat surface, without any separation of the knots. If a stippler is held up, and water allowed to drain from it until the brush becomes dry, each knot will stand apart from its fellows like so many separate pencils. This disarrangement of the bristles is soon corrected by rubbing the hand a few times across the surface of the brush when it is quite dry. This will cause the bristles to assume their former positions.

Stencil brushes are made in two forms. In one the bristles are fixed in the tapering end of a tin ferrule, and secured with a peculiar cement, the wooden handle, called a "knob," being inserted in the wide end of the ferrule. The other stencil brush is made by inserting the bristles in a wooden handle made to receive them. They are fastened with cement, and tied round with string.

Mottlers and grainers are made with high-class bristles inserted in tin casings of varying widths and thicknesses. In the grainers the bristles are unusually long for the thickness. In the mottlers they are shorter, so as to offer greater resistance to pressure when in use.

The *pencil grainer* is a special tool made by inserting small knots of bristles in separate tubes, each coming to a fine point. The tubes are inserted in a tin casing, each piece of casing having a wood filling fitted into the bottom of it.

From the foregoing description of the material used in the manufacture of painters' brushes it is obviously a

matter of importance that the purchaser should know the quality of any brushes he may be buying, as the present high price of bristles encourages adulteration and inferior materials. First, then, it is necessary to guard against the tendency to purchase brushes because they are cheap, for all cheap brushes turn out to be more expensive in the end than the comparatively dearer ones. It is easy to test the quality of any two brushes by using them constantly on the same kind of work. If this is done, it will be found that the low-price brush has considerably less spring, and will wear out much faster than the high-price one. The two chief adulterants used in painters' brushes are horsehair and fibre, both being blended with the bristles, and though there may be a difficulty at times in detecting the horsehair, there is none whatever in detecting the fibre, for it can be singled out by applying a lighted match to it, when the whole will burn slowly like straw. Under a similar test bristle or hair will frizzle up, giving off that smell peculiar to animal matter. Horsehair is mainly detected by being of the same thickness at one end as at the other, and in addition it has no spring. The genuine bristle is much thicker at the butt than at the top; but this remark does not, of course, apply to bristles which have been shortened in process of manufacture, for they show little difference in this respect.

Before using a paint or distemper brush, care should be taken to ascertain that it has not become too dry (some dealers hang them in bundles to the ceiling of their shops over gas-lights), as in such a case there is a tendency for some of the bristles to lose their hold, owing to shrinkage of the handle and other materials used to secure them. Such brushes may be placed in water for a short time; but it is wholly unnecessary to soak a brush for any lengthened period under the impression that this treatment will prevent the bristles from coming out. In using a brush for the first time, a few bristles will probably work out; but these are in most cases short ones which have been included by accident when making up the brush, and they gradually work their way outwards, not having been caught in the cement. Loose hairs may in most cases be removed by holding the brush-handle firmly and jerking it smartly, or by scraping the top of the brush with the blade of a knife; this latter will catch the butt end of the bristles and remove them, thus obviating the necessity of picking them off the wet paint. After using a brush care should be taken not to place it in a position where the bristles may get cramped, neither should paint be allowed to dry in it.

When practicable, brushes should be cleaned after using, and hung up ready for use; but if left to soak, it should be in oil or water, never in turpentine. A dirty brush should *not* be cleaned with hot water and potash, for this caustic alkali will cause the bristles to curl up as if they were dipped in lime. Varnish brushes should always be placed in oil and never in water. A builder should instruct his storekeeper to look after his brushes, especially when they are in use; unfortunately, it is not always necessary to employ such a man, and many high-class brushes are in consequence ruined for want of ordinary care. Builders should not purchase a brush which has not the maker's name stamped on the handle;—good makers have a reputation to lose, and they will therefore take care that all goods bearing their name shall be characterised by good material and good workmanship. ('English Mechanic.')

The Application of Paint.—Paint consists essentially of two parts—(1) the vehicle or medium, and (2) the pigment. In the case of oil-paints, a third substance becomes necessary, to facilitate the drying or solidification of the vehicle; this is termed a "drier."

Vehicles.—A perfect vehicle mixes

readily with the pigment, forming a mass of about the consistence of treacle. It is colourless, and has no chemical action upon the pigments with which it is mixed. When spread out in a thin layer upon a non-porous substance, it solidifies, and forms a film not liable to subsequent disintegration or decay, and sufficiently elastic to resist a slight concussion. No vehicle complies with all these conditions; those which most nearly approach them are the drying-oils. The use of oil in painting is said to have been invented in the 14th century, and soon reached considerable perfection. Even the best of recent painters have not succeeded in giving to their works that durability which the originators of the method attained. All organic substances are liable to a more or less rapid oxidation, especially if exposed to light and heat. Oil is no exception to this rule; but it seems that, in its pure state, it is much more durable than when mixed with other substances. Although ground-nut- and poppy-oils are sometimes employed by artists where freedom from colour is essential, linseed-oil is the vehicle of by far the larger proportion of paint for both artistic and general purposes.

Oil-paint appears to have been unknown to the ancients, who used various vehicles, chiefly of animal origin. One of these, which was in high repute at Rome, was white-of-egg beaten with twigs of the fig-tree. No doubt the indiarubber contained in the milky juice exuding from the twigs contributed to the elasticity of the film resulting from the drying of this vehicle. Pliny was aware of the fact that when glue is dissolved in vinegar and allowed to dry, it is less soluble than in its original state. Many suggestions have been made in modern times for vehicles in which glue or size plays an important part. In order to render it insoluble, various chemicals have been added to its solution, such as tannin, alum, and a chromic salt. None of these vehicles, however useful for special purposes, has become sufficiently well known to warrant description.

Storing.—When paint is not intended for immediate use, it is packed in metallic kegs. For exportation to hot climates, the rim of the lid is soldered down, a practice which effectually prevents access of atmospheric oxygen. White-lead paint is frequently packed in wooden kegs; these prevent the discoloration sometimes caused by iron kegs. When paint is mixed ready for use, it will, if exposed to the air, become covered with a skin, which soon attains sufficient thickness to exclude atmospheric oxygen, and prevent any further solidification of the oil. The paint may be still better protected by pouring water over it, or it may be placed in air-tight cans. If it has been allowed to stand for some time, it must be well stirred before using, as the pigments have a tendency not only to separate from the oil, but also to settle down according to their specific gravity.

Applying.—Of whatever nature the surface may be to which the paint is to be applied, great care must be taken that it is perfectly dry. Wood especially, even when apparently dry, may on a damp day contain as much as 20 per cent. of moisture. A film of paint applied to the surface of wood in this condition prevents the moisture from escaping, and it remains enclosed until a warm sun or artificial heat converts it into vapour, which raises the paint and causes blisters. Moisture enclosed between two coats of paint has the same effect. Paint rarely blisters when applied to wood from which old paint has been burnt off; this is probably due to the drying of the wood during the operation of burning.

Priming.—The first coat of paint applied to any surface is termed the "priming-coat." It usually consists of red-lead and boiled and raw linseed-oil. Experience has shown that such a priming not only dries quickly itself, but also accelerates the drying of the next coat. The latter action must be attributed to the oxygen contained in the red-lead, only a small portion of which

is absorbed by the oil with which it is mixed. Kall, of Heidelberg, prepares a substitute for boiled oil by mixing 10 parts whipped blood, just as it is furnished from the slaughter-houses, with 1 part of air-slaked lime sifted into it through a fine sieve. The two are well mixed, and left standing for 24 hours. The dirty portion that collects on top is taken off, and the solid portion is broken loose from the lime at the bottom; the latter is stirred up with water, left to settle, and the water poured off after the lime has settled. The clear liquid is well mixed up with the solid substance before mentioned. This mass is left standing for 10 or 12 days, after which a solution of potash permanganate is added, which decolorises it and prevents putrefaction. Finally the mixture is stirred up, diluted with more water to give it the consistence of very thin size, filtered, a few drops of oil of lavender added, and the preparation preserved in closed vessels. It is said to keep a long time without change. A single coat of this liquid will suffice to prepare wood or paper, as well as lime or hard plaster walls, for painting with oil colours. This substance is cheaper than linseed-oil, and closes the pores of the surface so perfectly that it takes much less paint to cover it than when primed with oil.

Drying.—The drying of paint is to a great extent dependent upon the temperature. Below the freezing-point of water, paint will remain wet for weeks, even when mixed with a considerable proportion of driers; while, if exposed to a heat of 120° F. (49° C.), the same paint will become solid in a few hours. The drying of paint being a process of oxidation and not evaporation, it is essential that a good supply of fresh air should be provided. When a film of fresh paint is placed with air in a closed vessel, it does not absorb the whole of the oxygen present; but after a time the drying process is arrested, and the remaining oxygen appears to have become inert. Considerable quantities of volatile vapours are given off during the drying of paint; these are due to the decomposition of the oil. When the paint has been thinned down by turpentine, the whole of this liquid evaporates on exposure to the air. There must, therefore, be a plentiful access of air, to remove the vapours formed, and afford a fresh supply of active oxygen. The presence of moisture in the air is rather beneficial than injurious at this stage. Especially in the case of paints mixed with varnish, moist air appears to counteract the tendency to crack or shrink. Under the erroneous impression that the drying of paint is a species of evaporation, open fires are sometimes kept up in freshly-painted rooms. It is only when the temperature is very low that any benefit can result from this practice: as a rule, it rather retards than hastens the solidification of the oil, which cannot take place rapidly in an atmosphere laden with carbonic acid. The first coat of paint should be thoroughly dry before the second is applied. Acrylic acid is formed during the oxidation of linseed-oil, and unless this be allowed to evaporate, it may subsequently liberate carbonic acid from the white-lead present in most paints, and give rise to blisters. Sometimes a second priming-coat is given; but usually the second coat applied contains the pigment. This, as soon as dry, is again covered by another coat, and subsequently by two or more finishing-coats, according to the nature of the work.

Filling.—Before the first coat is applied to wood, all holes should be filled up. The filling usually employed is ordinary putty; this, however, sometimes consists of whiting ground up with oil foots of a non-drying character, and when the films of paint are dry, the oil from the putty exudes to the surface causing a stain. The best filling for ordinary purposes is whiting ground to a paste with boiled linseed-oil. For finer work, and for filling cracks, red-lead mixed with the same vehicle may be employed. For porous hard woods, use boiled oil and corn starch stirred into a very thick paste; add a little japan, and reduce with turpentine.

Add no colour for light ash; for dark ash and chestnut, use a little raw sienna; for walnut, burnt umber and a slight amount of Venetian red; for bay wood, burnt sienna. In no case use more colour than is required to overcome the white appearance of the starch, unless you wish to stain the wood. This filler is worked with brush and rags in the usual manner. Let it dry 48 hours, or until it is in condition to rub down with No. 0 sandpaper, without much gumming up; and if an extra fine finish is desired, fill again with the same materials, using less oil, but more japan and turpentine. The second coat will not shrink, being supported by the first. When the second coat is hard, the wood is ready for finishing up by following the usual methods. This formula is not intended for rosewood.

Coats.—There is no advantage in laying on the paint too thickly. A thick film takes longer to dry thoroughly than two thin films of the same aggregate thickness. Paint is thinned down or diluted with linseed-oil or turpentine. The latter liquid, when used in excess, causes the paint to dry with a dull surface, and has an injurious effect upon its stability. Sometimes the last coat of paint is mixed with varnish, in order to give it greater brilliance. In this case, special care must be taken that the previous coats have thoroughly solidified, or cracks in the final coat may subsequently appear. The same remark applies when the surface of the paint is varnished. The turpentine with which the varnish is mixed has a powerful action upon the oil contained in the paint, if the latter is not thoroughly oxidised. The exterior of the paint is thus softened, and the varnish is enabled to shrink and crack, especially in warm weather.

Surface.—When the surface to be painted is already covered with old paint, this should be either removed or rubbed down smooth before applying the new. When the thickness of the old coat is not great, rubbing down, accompanied by a careful scraping of blisters and defective parts, will suffice. When the thickness of the old paint necessitates its removal, it may either be burnt off, or softened by a solution of caustic alkali, and afterwards scraped. The burning process is the most effective, and leaves the wood in a fit condition to receive the fresh coat of paint; but it is not applicable in the case of fine mouldings. When caustic potash or soda is used, the paint is left in contact with it for some time, when the linoleic acid of the oxidised linseed-oil becomes saponified, and can easily be scraped or scrubbed off the surface of the wood. Whenever an alkali is employed, it is of the greatest importance that the wood should afterwards be thoroughly washed several times with clean water, in order to remove every trace of the solvents. Any soda or potash remaining in the pores of the wood would not only retain moisture and cause blistering, but would also have an injurious action upon the vehicle of the paint subsequently applied, and in many cases upon the pigment itself. The remarks already made as to the necessity of an absolutely dry surface should be borne in mind in this instance. When the surface of the paint is to be protected by a coat of varnish, the latter should not be applied until the whole of the oil contained in the paint has solidified. The wrinkling of varnish upon paint is frequently erroneously attributed to the bad quality of the varnish, when the real cause is the incomplete oxidation of the paint itself.

Removing Smell.—(1) Place a vessel of lighted charcoal in the room, and throw on it 2 or 3 handfuls of juniper berries; shut the windows, the chimney, and the door close; 24 hours afterwards the room may be opened, when it will be found that the sickly, unwholesome smell will be entirely gone. (2) Plunge a handful of hay into a pail of water, and let it stand in the room newly painted.

Discoloration. — Light - coloured paints, especially those having white-lead as a basis, rapidly discolour under

different circumstances. Thus white paint discolours when excluded from the light; stone colours lose their tone when exposed to sulphuretted hydrogen, even when that is only present in very small quantity in the air; greens fade or darken, and vermilion loses its brilliance rapidly in a smoky atmosphere like that of London. Ludersdorf thinks that the destructive change is principally due to a property in linseed-oil which cannot be destroyed. The utility of drying oils for mixing pigments depends entirely on the fact that they are converted by the absorption of oxygen into a kind of resin, which retains the colouring pigment in its semblance; but during this oxidisation of the oil—the drying of the paint—a process is set up which, especially in the absence of light and air, soon gives the whitest paint a yellow tinge. Ludersdorf therefore proposes to employ an already formed but colourless resin as the binding material of the paint, and he selects two resins as being specially suitable—one, sandarach, soluble in alcohol; the other, dammar, soluble in turpentine. The sandarach must be carefully picked over, and 7 oz. is added to 2 oz. Venice turpentine and 24 oz. alcohol of sp. gr. 0·833. The mixture is put in a suitable vessel over a slow fire or spirit-lamp, and heated, stirring diligently, until it is almost boiling. If the mixture be kept at this temperature, with frequent stirring, for an hour, the resin will be dissolved, and the varnish is ready for use as soon as cool. The Venice turpentine is necessary to prevent too rapid drying, and more dilute alcohol cannot be employed, because sandarach does not dissolve easily in weaker alcohol, and, furthermore, the alcohol, by evaporation, would soon become so weak that the resin would be precipitated as a powder. When this is to be mixed with white-lead, the latter must first be finely ground in water, and dried again. It is then rubbed with a little turpentine on a slab, no more turpentine being taken than is absolutely necessary to enable it to be worked with the muller; 1 lb. of the white-lead is then mixed with exactly ¼ lb. of varnish, and stirred up for use. It must be applied rapidly because it dries so quickly. If when dry the colour is wanting in lustre, it indicates the use of too much varnish. In such cases, the article painted should be rubbed, when perfectly dry, with a woollen cloth to give it a gloss. The dammar varnish is made by heating 8 oz. dammar in 16 oz. turpentine oil at 165° to 190° F. (74° to 88° C.), stirring diligently, and keeping it at this temperature until all is dissolved, which requires about an hour. The varnish is then decanted from any impurities, and preserved for use. The second coat of the pure varnish, to which half its weight of oil of turpentine has been added, may be applied. It is still better to apply a coat of sandarach varnish made with alcohol, because dammar varnish alone does not possess the hardness of sandarach, and when the article covered with it is handled much, does not last so long.

The Scaling of Paint.—It is always found that when paint "scales" that there is every indication of a want of adhesion to the surface on which it is laid, and although this is easy to understand, it is more difficult to say what causes this ill result. Undoubtedly the surface on which the paint is laid is usually at fault and requires the chief consideration. If wood is in question then the presence of one or other or a combination of three conditions is usually sufficient to induce flaking. These conditions are: moisture in or on the wood; resinous matter in the wood; the interposition of a film of size which by its very nature does not form a permanent coating over the wood, and therefore is a source of weakness to every coat of paint laid over it. In the case of iron and steel, a fruitful source of scaling is rusting under the surface of the paint. Want of care in cleaning the surface before painting induces the formation of rust beneath the surface, and the presence of "mill-scale" will

cause flaking of a purely mechanical kind. The use of unsuitable though not necessarily bad materials also causes iron and steel to rust under the paint, and the most recent investigations on the subject tend to prove that linseed-oil is the unreliable element in the case, as it does not resist the passage through it of moisture and carbonic acid gas, which are the prime causes of rusting. Cement surfaces exhibit some curious traits in regard to the scaling of paints, as the causes that operate are somewhat complex. Very often the active chemical matter in the cement is sufficient to destroy the oil in that portion of the paint that lies nearest to it, with the consequence that the adhesion of the whole film is destroyed, and flaking results. Again, a cement surface (and this refers particularly to an old cement surface, or to one that has been previously treated with cement wash or distemper) is extremely liable to contain a quantity of loose powdery matter, and unless this is carefully and thoroughly brushed off before painting operations are begun, flaking will inevitably occur. Still another cause is the excessive porosity of many cement surfaces. The liquid portion of the paint is rapidly sucked up, leaving the solid pigmentary portion on the surface. This solid portion being robbed of the binding medium, then forms in itself a powdery layer, and prevents the succeeding coats of paint attaching themselves firmly to the surface of the cement. Here, then, we have that lack of adhesion which will cause flaking.

Practical Hints.—The composition of paints should be governed —(1) by the nature of the material to be painted: thus the paints respectively best adapted for wood and iron differ considerably; (2) by the kind of surface to be covered—a porous surface requires more oil than one that is impervious; (3) by the nature and appearance of the work to be done: delicate tints require colourless oil, a flatted surface must be painted without oil (which makes the gloss of a shining surface), paint for surfaces intended to be varnished must contain a minimum of oil; (4) by the climate and the degree of exposure to which the work will be subjected: for outside work, boiled oil is used, because it weathers better than raw oil, turps is avoided as much as possible, because it evaporates and does not last; if, however, the work is to be exposed to the sun, turps is necessary to prevent the paint from blistering; (5) the skill of the painter affects the composition; a good workman can lay on even coats with a smaller quantity of oil and turps than one who is unskilful; extra turps, especially, are often added to save labour; (6) the quality of the materials makes an important difference in the proportions used: thus more oil and turps will combine with pure than with impure white-lead; thick oil must be used in greater quantity than thin; when paint is purchased ready ground in oil, a soft paste will require less turps and oil for thinning than a thick; (7) the different coats of paint vary in their composition: the first coat laid on to new work requires a good deal of oil to soak into the material; on old work, the first coat requires turpentine to make it adhere; the intermediate coats contain a proportion of turpentine to make them work smoothly; and to the final coats the colouring materials are added, the remainder of the ingredients being varied according as the surface is to be glossy or flat.

The exact proportions of ingredients best to be used in mixing paints vary according to their quality, the nature of the work required, the climate, and other considerations. The composition of paint for different coats also varies considerably. The proportions given in the following table must only be taken as an approximate guide when the materials are of good quality.

For every 100 sq. yd., besides the materials enumerated in the foregoing, $2\frac{1}{4}$ lb. white-lead and 5 lb. putty will be required for stopping. The area

TABLE showing the COMPOSITION of the different COATS of WHITE PAINT, and the QUANTITIES required to cover 100 sq. yd. of NEWLY-WORKED PINE.

	Red-lead.	White-lead.	Raw Linseed-oil.	Boiled Linseed-oil.	Turpentine.	Driers.	REMARKS.
Inside work, 4 coats not flatted.	lb.	lb.	pt.	pt.	pt.	lb.	
Priming	½	16	6	—	—	¼	Sometimes more red-lead is used and less driers.
2nd coat	*	15	3½	—	1½	¼	* Sometimes just enough red-lead is used to give a flesh-coloured tint.
3rd coat	—	13	2½	—	1½	¼	
4th coat	—	13	2½	—	1½	¼	
Inside work, 4 coats and flatting.							
Priming	1½	16	6	—	½	1–8	
2nd coat	—	12	4	—	1½	1–10	
3rd coat	—	12	4	—	0	1–10	
4th coat	—	12	4	—	0	1–10	
Flatting	—	9	0	—	3½	1–10	
Outside work, 4 coats not flatted.							When the finished colour is not to be pure white, it is better to have nearly all the oil boiled oil. All boiled oil does not work well. For pure white, a larger proportion of raw oil is necessary, because boiled oil is too dark.
Priming	2	18½	2	2	—	1–8	
2nd coat	—	15	2	2	¼	1–10	
3rd coat	—	15	2	2	½	1–10	
4th coat	—	15	3	2½	0	1–10	

which a given quantity of paint will cover depends upon the nature of the surface to which it is applied, the proportion of the ingredients, and the state of the weather. When the work is required to dry quickly, more turpentine is added to all the coats. In repainting old work, two coats are generally required, the old paint being considered as priming. Sometimes another coat may be deemed necessary. For outside old work exposed to the sun, both coats should contain 1 pint turpentine and 4 pints boiled oil, the remaining ingredients being as stated in the foregoing table. The extra turpentine is used to prevent blistering. In cold weather, more turpentine should be used to make the paint flow freely.

Surface painting is measured by the superficial yd., girting every part of the work covered, always making allowance for the deep cuttings in mouldings, carved work, railings or other work that is difficult to get at. Where work is very high, and scaffolding or ladders have to be employed, allowances must be made. The following rules are generally adopted in America in the measurement of work: Surfaces under 6 in. in width or girt are called 6 in.; from 6 to 12 in., 12 in.; over 12 in., measured superficial. Open-

ings are deducted, but all jambs, reveals, or casings are measured girt. Sashes are measured solid if more than two lights. Doors, shutters and panelling are measured by the girt, running the tape in all quirks, angles or corners. Sash doors measure solid. Glazing in both windows and doors is always extra. The tape should be run close in over the battens, on batten doors, and if the stuff is beaded, add 1 in. in width for each bead. Venetian blinds are measured double. Dentels, brackets, medallions, ornamented iron work, balusters, lattice work, palings, or turned work, should all be measured double. Changing colours on base boards, panels, cornices, or other work, one-fourth extra measurement should be allowed for each tint. Add 5 per cent. to regular price for knotting, puttying, cleaning, and sandpapering. For work done above the ground floor, charge as follows: Add 5 per cent. for each storey of 12 ft. or less, if interior work; if exterior work, add 1 per cent. for each ft. of height above the first 12 ft.

Paint Removers.—(1) 15 lb. quick-lime, slaked to a cream, add 5 lb. pearlash, and mix well. Paint this over the work to be treated and leave for a night (say 14 hours), and the old paint can then be readily scraped off.

(2) Mix and grind well together to the consistence of paint, 3½ gal. of water, 3 qt. of paraffin or petroleum, 7 lb. caustic soda, and 6 lb. of peat-moss litter, or spent tan.

To Remove Putty.—Take equal parts of quicklime and carbonate of potash or soda. Slake the lime with water just enough to make it into a powder. Mix the whole to a paste with water and spread it on to the putty. Repeat the application, if necessary. Occasionally soft soap is used with this to prevent it drying too quickly.

It is well known that putty can be softened, when it is convenient, by the application of a moderately hot iron. The iron should be as hot as will do no injury to glass or wood in contact with the putty.

Driers.—Of these there are several kinds, but the best usually have litharge or sugar of lead as the important "drying" agent. Litharge is best for dark and middle tints, while sugar of lead is better suited for light tints.

Drier with Litharge.—Litharge, 1½ lb.; whiting, 5 lb.; barytes, 3 lb.; sugar of lead, 1½ lb.; sulphate of zinc, 2½ lb.; white-lead, 1½ lb.; refined linseed-oil, ½ gal.

Another.—Litharge, 3 lb.; Paris white, 19 lb.; barytes, 19 lb.; sugar of lead, 1 lb.; white copperas, 4 lb.; raw linseed-oil, 10 lb. The litharge, sugar of lead, and copperas are put in a pan with some of the oil and allowed to stand a day or two. It is then stirred and more oil added and left for a further time. This is done until all the oil is used, taking 9 or 10 days. It is then ground with the other ingredients.

Drier with Sugar of Lead.—Sugar of lead, 9 lb.; white-lead, 2½ lb.; whiting, 1½ lb.; boiled linseed-oil, 1 qt. The dry ingredients are well ground in the oil, good grinding being essential.

Patent Drier.—Grind together ½ lb. ground litharge, 1 lb. white sugar of lead, 12 lb. barytes, 2 lb. whiting, ½ lb. dry white-lead, 1 lb. sulphate of zinc, and 2½ lb. boiled linseed-oil.

Drier without Litharge or Sugar of Lead.—5 lb. barytes, 5 lb. whiting, 1 lb. dry white-lead, and 1 qt. boiled linseed-oil. Well mix the dry ingredients, then grind with the oil.

Another.—½ lb. borate of manganese; 6 lb. carbonate of zinc, 6 lb. linseed-oil. Mix the two dry ingredients, then grind in the oil.

Drier without Oil (used in powdered form, sprinked into the paint as required).—Oxide of zinc, 3 lb.; borate of manganese, 4 lb.; barytes, 11 lb. To be ground very fine and kept dry in a box or tin.

Terebene Drier.—1½ gal. boiled linseed-oil, 7 lb. litharge, 1 lb. black oxide of manganese, 6 gal. of turpentine. Put the oil on to get hot; then add the litharge, a little at the time, stirring until dissolved. Add the man-

ganese, stirring at the time. Remove the vessel from the fire and, when cooled a little, add the turpentine. This is a paint drier (1 oz. of drier to 1 lb. of paint); if required for varnish-making, use 1 gal. less turpentine.

Another. — Medium rosin, 7 lb.; boiled linseed-oil, 12 lb.; litharge, 5 lb.; resinate or borate of manganese, 1 lb.; turpentine, 6 gal. The rosin should be first melted, then the oil added, and heated up to receive the dry ingredients. It is then allowed to fairly cool before adding the turpentine (to avoid the risk of the latter igniting).

Driers for Zinc-White.—Since it has been tried to substitute zinc oxide or zinc-white for white-lead in painting, researches have been made to replace litharge as a drier by a substance free from the inconveniences which caused the abandonment of white-lead. If sulphuretted hydrogen impairs the whiteness of painting done with white-lead, it is not logical to employ a lead drier with zinc paints, because the latter substances will lose their advantage of not becoming dark. Several metallic oxides and salts, especially zinc sulphate, manganese oxide, and umber, have the property of combining with oils, which they render drying. To these may be added the protoxides of the metals of the third class, i.e., iron, cobalt, and tin. But these oxides are very unstable and difficult of preparation; hence it became desirable to discover some means by which they might be combined with bodies which would enable them to be prepared cheaply, and at the same time leave unimpaired their desiccating powers. Moreover, it is acknowledged that driers in the dry state are preferable in many respects to drying oils. Following are some of the recently introduced driers:—

(1) Cobalt and Manganese Benzoates. —Benzoic acid is dissolved in boiling water, the liquid being continually stirred, and neutralised with cobalt carbonate until effervescence ceases. Excess of carbonate is removed by filtration, and the liquor is evaporated to dryness. The salt thus prepared is an amorphous, hard, brownish material, which may be powdered like rosin, and kept in the pulverulent state in any climate, simply folded in paper. Painting executed with a paint composed of 3 parts of this drier with 1000 of oil and 1200 of zinc-white, dries in 18 to 20 hours. Manganese benzoate is prepared in the same way, substituting manganese carbonate for that of cobalt. Applied under similar circumstances, it dries a little more rapidly, and a little less is required. Urobenzoic (hippuric) acid is equally efficacious.

(2) Cobalt and Manganese Borates. —These salts also, in the same proportions, are found to be of equal efficacy. The latter is extremely active, and requires to be used in much smaller proportions.

(3) Resinates.—If an alkaline resinate of potash or soda be dissolved in hot water, and this solution be precipitated by a solution of a proportionate quantity of a cobalt or manganese chloride or sulphate, an amorphous resinate is formed, which, after being collected on cloth filters, washed, and dried, forms an excellent drier.

(4) Zumatic (Transparent) Drier.— Take zinc carbonate, 90 lb.; manganese borate, 10 lb.; linseed-oil, 90 lb. Grind thoroughly, and keep in bladders or tin tubes. The latter are preferable.

(5) Zumatic (Opaque) Drier.—Manganese borate, as a drier, is so energetic that it is proper to reduce its action in the following way: Take zinc-white, 25 lb.; manganese borate, 1 lb. Mix thoroughly, first by hand, then in a revolving drum; 1 lb. of this mixed with 20 lb. paint ensures rapid drying.

(6) Manganese Oxide.—Purified linseed-oil is boiled for 6 or 8 hours, and to every 100 lb. boiled oil are added 5 lb. of powdered manganese peroxide, which may be kept suspended in a bag, like litharge. The liquid is boiled and stirred for 5 or 6 hours more, and then cooled and filtered. This drying oil is employed in the proportion of 5 to 10 per cent. of the zinc-white.

(7) Guynemer's.—Take pure manganese sulphate, 1 part; manganese acetate, 1 part; calcined zinc sulphate, 1 part; white zinc oxide, 97 parts. Grind the sulphates and acetate to impalpable powder, sift through a metallic sieve. Dust 3 parts of this powder over 97 of zinc oxide, spread out over a slab or board, thoroughly mix, and grind. The resulting white powder, mixed in the proportion of ½ or 1 per cent. with zinc-white, will enormously increase the drying property of this body, which will become dry in 10 or 12 hours.

Knotting.—5 oz. or ½ gill japanners' gold size, 1 pint naphtha, 6 oz. orange shellac, 1 oz. red-lead. The lead may be omitted if desired.

Another.—Shellac, 4 lb.; methylated spirits, 5 pints; Venice turpentine, ½ gill. The turpentine may be omitted if desired.

Another.—Shellac, 7 lb.; amber rosin, 3 lb.; methylated spirit, 2 gal.

Cheap Knotting.—Make some glue size hot, and work in as much red-lead as possible. Apply warm.

Priming Paints. — *Priming Paint for Outside Work.*—7 lb. white-lead, 3 pints boiled linseed-oil, ¼ lb. red-lead, 2 oz. driers. When dry, rub down with glass paper or pumice stone, and stop all holes with putty.

Priming Paint for Inside Work.—7 lb. white-lead, 3 pints raw linseed-oil, ¼ lb. red-lead, and 2 oz. driers. When dry, rub down with glass paper or pumice stone, and stop all holes with putty.

Putty and Fillers.—*Putty, Ordinary.*—¼ cwt. whiting, 1 gal. raw linseed-oil. Well crush the whiting and dry it. If heat is used for drying, let the whiting get cold before adding the oil.

Putty, Superior, for Outside Work, Conservatories, etc.—¼ cwt. whiting, 1 gal. raw linseed-oil, 2 lb. red-lead. If heat is used, let the dry ingredients get cold before adding the oil. Be sure let all be cool before putting into barrels.

A better Putty for Outside Work.—20 lb. whiting, [illegible] lb. white-lead. Grind to proper consistence with boiled linseed-oil.

French Putty.—14 lb. linseed-oil, 8 lb. burnt umber. Boil together for about 2 hours. Next add 20 lb. white-lead and 11 lb. whiting.

Quick Setting Putty.—¼ cwt. whiting, 4 lb. litharge, 1 lb. driers, ½ gal. raw linseed-oil. More oil may be added if found necessary.

Cheapest Putty.—¼ cwt. whiting, 1 lb. linseed-oil, 1 lb. resin oil (drying), 2 lb. linseed-oil substitute.

Quick-setting Putty for Cabinet Work.—Make some very thin glue, and while warm add Plaster of Paris to the required consistence. This should be used immediately as it sets quickly.

Putty Composition as used for Picture Frame Ornamentation.—Make some glue of medium strength, and, while hot, mix whiting until the consistence of putty is obtained. Shape it at once into leaves, studs, or whatever ornament is desired, and it will set with a moderately tough hardness.

Coloured Putty.—Dry powdered colours such as umber, ochre, Venetian red, yellow chrome, rose pink, Vandyke brown, can be used, but are best mixed with the dry whiting before the oil is added. More oil will be required according to the amount of dry colour added.

Fillers. Filling-up Powder.—Silica, 12 lb.; China clay, 2 lb.; raw linseed-oil, 6 qt.; turpentine, 6 qt.; thin drier, ½ pint.

Filling-up Liquid.—China clay, 10 lb.; raw linseed-oil, 7 pints; turpentine, 1 gal.; rosin varnish, 2 gal.

Fire-Proof Paints.—In a paper communicated to the Paint and Varnish Society, M. Ch. C. Coffignier pointed out that all the fire-proof paints known up to the present day owe their particular properties to the presence of ammoniacal salts, and their fireproofing action is due to the liberation of ammonia on heating.

The following formulæ for fireproofing compositions are given by Mons. J. A. Martin:—

		Parts
1.	Sulphate of ammonia	8
	Carbonate of ammonia	2½
	Boric acid	3
	Borax	3
	Starch	2
	Water	1000
		Grs.
2.	Ammonium hydrochloride	150
	Boric acid	50
	Animal glue	500
	Gelatine	15
	Water	1000
3.	Ammonia hydrochloride	80
	Boric acid	30
	Borax	20
	Water	1000
4.	Ammonia sulphide	80
	Boric acid	30
	Borax	20
	Water	1000

By adding whitening to No. 2 formulæ, M. Martin professes to produce a fireproof coating, but with very indifferent success. Moreover, all these salts of ammonia are soluble, and it will be readily understood that their use is not conducive to the preparation of high-class paints.

It is the same as regards paints with an asbestos base. These paints settle very rapidly, and the difficulty experienced in putting them right again is a serious drawback. It must also be added that they are very alkaline, and that is even a more serious drawback. In fact, the coating they produce cannot be compared even with the commonest paint. Some time ago, in conjunction with M. Verine, the author investigated the possibility of using magnesium ammonium phosphate, which is the only insoluble ammoniacal salt, and consequently may enter without ill effects into the composition of a paint. He found that this salt generated ammonia at a temperature of 150° C., and that by simply incorporating it with ordinary paint, a coating is produced which is already less combustible than ordinary paint; but we obtained a much more decisive result by preparing a special varnish, having as a basis a metallic salt of linoleic acid, linoleate of lead for preference, dissolved in turpentine or benzine.

In order to obtain a fireproof paint it will be sufficient to grind the following mixture with this varnish:—

	Kg.
Powdered asbestos	75
Magnesium ammonium phosphate	75
Powdered white lead	100

The white lead may be replaced by any other pigment. As far as the use of asbestos is concerned, it is not indispensable, but it reduces the cost of the paint.

Graining. GROUNDS. — Ground colours are generally applied by the painter, ready for the grainer. When the grounds are finished to the tint required for the woods to be imitated, they must be left to get quite dry; the work is then ready for the graining operations.

COLOURS.—The colours used to give the various effects are as follows:—

Bird's-eye Maple and Satin Wood. —White-lead mixed with a little yellow ochre, care being taken not to make the ground of too dark a tint, as the varnish to be afterwards applied will still further darken it. All the colours for light grounds must be rubbed quite smooth, and be well strained.

Light Maple.—2 parts French ochre, 200 parts white-lead.

Dark Maple.—2 parts dark golden ochre, 200 parts white-lead.

Mahogany. —(1) Orange chrome, Venetian red, and white-lead mixed in such proportions as will give the desired tint. Vermilion, raw and burnt sienna are also employed to modify the shades.

(2) 2 parts burnt sienna, 10 parts orange chrome, 20 parts white-lead.

Rosewood. — Vermilion, Venetian red, a little scarlet lake, and white-lead. For ordinary work the scarlet lake may be dispensed with.

Ash.—1 part French ochre, 100 parts white-lead. A very small portion, say

½ part, of raw Turkey umber may be added.

Oak. — Dark. — (*a*) Raw sienna, burnt umber, white-lead, and Venetian red.

(*b*) Yellow ochre, Venetian red, and white-lead.

Dark wainscot. — Oxford ochre, white-lead and Venetian red; or chrome, yellow ochre, and white-lead.

Light.—Yellow ochre and white-lead; the desired tint is obtained by the use of more or less of the yellow ochre.

Walnut.—2 parts dark Venetian red, 2 parts drop black, 6 parts dark golden ochre, 100 parts white-lead.

Cherry.—2 parts raw sienna, 10 parts burnt sienna, 200 parts white-lead.

STYLES. — *Bird's-eye Maple.* — (*a*) Graining colour—equal parts of raw sienna and burnt umber mixed in ale, of two thicknesses. First lay on an even coat of the thinner mixture, then with a smaller brush put in the darker shades, mottle and soften with a badger-hair brush. The eye is imitated by dabbing the colour whilst still wet with the tops of the fingers. When dry, put on the top grain in the most prominent places, and shade the eyes with a little burnt sienna. Some grainers use small brushes called maple eye-dotters, instead of the fingers, for forming the eyes. Various forms of brushes are used for the mottling; some consist of short camel hair closely set, whilst to give the wavy appearance hog-hair mottlers are used, with long hairs, against which the fingers are pressed as the brush is drawn over the work, causing it to assume a variety of pleasing curves. The lines to imitate the heart of the wood are put in with a small brush, and the outer lines parallel to the heart are formed with the overgraining brush. Overgraining brushes for maple consist of a number of small sable brushes mounted at a little distance from each other in a frame, and resembling a comb in its appearance.

(*b*) Grind equal parts of raw and burnt sienna in a mixture of water and ale. Coat the work evenly with this colour, then rub it down with a long piece of buff leather, cut straight at the edge and pressed closely against the work. Proceed for the imitation of the eyes and heart of the wood as before directed.

(*c*) For outside work grind the raw and burnt sienna with a little of the patent driers, and then with boiled oil. Lay on an even coat, and rub down with a piece of buff leather. Soften, and when dry put on a top grain of burnt umber and raw sienna ground in ale.

(*d*) Burnt umber or Vandyke brown laid on unevenly, darker in some places than in others, after the character of the wood; a coarse sponge does for this purpose very well.

When the colour is disposed over the surface it must be softened down with the badger-hair tool, and the knots put in with the end of a hog's-hair fitch, by holding the handle between the thumb and finger, and twisting it round; these knots may be afterwards assisted by a camel-hair pencil. A few small veins are frequently found in maple; these may be wiped off with a piece of wash-leather. When this is dry, the second or upper grain may be put on; some of the first colour diluted will do for this second grain. To put on this grain, use the flat hog-hair brush, and the hairs combed out to straighten or separate them. As soon as the grain is put on, the softener should be passed lightly across the grain in one direction only; this will make one edge of the grain soft and the other sharp, as it occurs in the wood. After the second grain is dry it may be varnished.

Hare-wood.—(*a*) First lay on a coat of light grey, of white-lead ground in boiled oil, add a little Prussian blue, and mix with turpentine. For ground colour use the same paint made much thinner with turpentine, laid on as soon as the first coat is dry. The ground colour must only be applied on a small piece at a time, as it must be grained before it dries. For the graining use some of the ground colour, to

which add a little Prussian blue, apply this with a feather, in long veins. Overgrain with the ground colour.

(*b*) Mix white-lead and turpentine, and add a little Prussian blue, for the ground colour. For the graining colour, Prussian blue and raw sienna ground in ale. When the ground is dry, lay on a thin coat of the graining colour and soften; put on a long grain with a mottler drawn across the work. Soften, and overgrain in a perpendicular but wavy figure.

Mahogany.—(*a*) Vandyke brown and a little crimson lake ground in ale laid on, allowed to dry and then smoothed, forms the ground. Then lay on a second thicker coat, soften with a badger-hair brush, take out the lights whilst it is wet, and imitate the feathery appearance of mahogany heart. Soften, and top grain with Vandyke brown laid on with an overgraining brush of flat hog-hair combed into detached tufts. In softening, be careful not to disturb the under colour.

(*b*) Grind burnt sienna and Vandyke brown in ale, lay on a coat, mottle with a camel-hair mottler, and soften. When dry, overgrain as above.

Oak in Distemper.—This process is now seldom used, although it stands exposure to the weather, without fading, for a great length of time. For colour, dissolve gum arabic in hot water, and make a mixture of it with whiting, raw sienna, and Vandyke brown ground in beer. Colour the work evenly, brush it down with a dry dusting brush, comb while the colour remains wet, then let it get quite dry. Put in the veins with a small brush dipped in clean cold water. After a few seconds, run a dry soft duster down the work to remove the colour from the veins. Then lay on a thin coat of Turkey umber ground in beer. Put on with an overgraining brush. If too much gum is put in the colour, it is likely to crack and blister; whilst if there is not sufficient, the veins will not be clearly marked by the wiping out.

Oak in Oil.—Vandyke brown and raw sienna for dark oak, or finely-ground burnt umber and raw sienna for a lighter tint, mixed with equal parts of turpentine and linseed-oil. Add patent driers. Lay this colour on thinly and evenly with a large brush; it does not dry very rapidly. Care must be taken not to lay on too much colour, or it is liable to have a dirty appearance. Stipple with a dry dusting brush, so as to distribute the colour evenly over the work. As in real oak it is invariably found that one side of a slab is coarser than the other, this peculiarity of pattern must be imitated in the combing process. Take a cross-cut gutta-percha comb, and draw it down one side of the panel; use a finer comb to complete it. This operation produces straight lines of the grain from top to bottom. Next take a fine steel comb, and go over all the previous combing; in drawing the comb down, give it a short, quick, wavy motion, or move it diagonally across the first few lines, thus imitating the pores of the real wood. Cork combs may also be used, and some grainers use a coarse steel comb, with a fold of thin rag placed over the teeth. By a skilful combination of the combs, and a tasteful variation in their use, the different kinds of oak may be most successfully imitated. In graining joints of the various portions of a piece of work, it must be remembered that in the real wood some of the grain would necessarily have a perpendicular direction, and another part would run horizontally, and that one part would appear lighter than another, owing to the different angles in which it would receive the rays of light. After combing, the figure or veining must be wiped out before the colour is dry. Hold several thicknesses of fine rag, or a piece of clean wash-leather over the thumb-nail, wipe down a few veins, then move the rag or leather slightly, so as to present a clean surface for the next wipe. A piece of thin gutta-percha, softened in warm water, and pressed to the shape of the thumb, may be used to preserve the nail, but

cannot be relied on to remove the colour so cleanly as the nail covered with rag or leather; it is useful for common work, as it protects the nail from injury and wear. After having wiped the figures, they must be softened in appearance by still further wiping the grain away from their edges with a small roll of clean rag, so as to imitate the appearance of the wood, where the grain is always darker than the parts next to it. When the oil colour is dry it must be overgrained.

Oak in Spirit Colour.—This is less durable than oak graining in oil, and is not therefore so much used for outside work, but it does not require so long a time in its working, as it dries rapidly. For the graining colour, rub up whiting in turpentine, add enough burnt umber and raw sienna, dilute with turps, a little boiled oil, and gold size. Strain carefully, and it is ready for use. In laying this on, cover only a small part of the work at a time before combing, as it dries very quickly, and be careful to spread it evenly and thinly over the work. The combs used are made of steel, horn, or leather. After combing the veins and removing any superfluous graining colour from corners or small parts of the work, let it stand for a short time. The flower of the wood has next to be imitated, by removing some portions of the graining colour with a small veining fitch. The spirit graining colour when used for this purpose must have a little turpentine added to it; apply with the fitch where the flower is required, then rub the places quickly with a piece of old flannel, which will remove the graining colour and show the light ground underneath. The light veins and half-lights are also obtained by similar means, either removing the graining colour or merely smudging it aside over the veins. The overgraining is performed in the manner described for the oak graining in oil.

Pollard Oak in Distemper.—The ground is a mixture of vermilion, chrome yellow, and white-lead, to a rich buff. The graining colours are Vandyke brown, a little raw and burnt sienna and lake, ground in ale. Fill a large tool, lay on an even coat, and soften with the badger-hair brush. Take a moistened sponge and dapple round and round in circles, then soften lightly, and draw a softener from one set of circles to the other while wet, to form a number of grains; finish the knots with a hair pencil. When dry, put the top grain on in a variety of directions, then a coat of turpentine and gold size mixed. When this is dry, glaze with Vandyke brown mixed in beer.

Pollard Oak in Oil.—Ground, the same as for pollard oak in distemper. Graining colours, equal portions of Vandyke brown and raw sienna, ground separately in boiled oil very stiff; mix them together, and thin the whole with spirit of turpentine. With a large brush lay on a thin coat, and, while wet, take the flat graining brush dipped in the colour, and dapple in various directions; then dip the brush into burnt umber thinned with spirit of turpentine, and form the knots. When the colours are set, dip a flat brush into a thin glaze of burnt umber, and then put the grain on in a curly direction. Have enough oil in the colours to bind them, and finish only a small part of the surface at once, in order to keep it moist. For making the knots a cork should be held on to a patch of the dark colour, and twisted round between the thumb and finger. The heart of the wood should be taken out with a graining fitch.

Rosewood.—Ground: chrome yellow, vermilion, and white-lead. For the graining colour, grind ivory black and burnt sienna very fine; mix, and lay on; then soften. When dry, put on the top grain in a curly figure, with a small graining brush well filled with ivory black. Shade up the knots with a camel-hair brush, and finish with a glaze of rose-pink.

Satin Wood.—(a) Graining colour. Equal parts of raw umber and raw sienna, a little whiting and burnt sienna, all ground in ale. Colour

evenly and soften; then mottle and feather same as for mahogany. Soften, and allow to dry; overgrain with the same colour.

(*b*) Grind raw sienna and whiting in ale very thin, and colour the surface. Soften whilst wet, and take out the lights with a mottling brush; when dry, overgrain with the same colour applied with a flat brush.

Yew.—Ground, reddish yellow. For graining colour, grind equal parts of Vandyke brown and burnt sienna in ale, with a little raw sienna. Lay this colour on evenly when the ground is dry, and soften. Cut a piece of cork to a tolerably sharp edge, rub it across the work, and soften the same way as the grain, as in curled maple. When dry, dab the work over with the graining colour on the tips of the fingers to form the knots; shade them underneath with a camel-hair brush. When dry overgrain.

GRAINING ROLLER.—This tool consists of a roller of wood or metal mounted on a spindle, to which are attached a frame and a handle. Around the wooden roller is a wrapper of leather, on which is cut or stamped an imitation of the grain of a certain wood. The leather used for the roller is of thick hide. The pattern is sketched on one side, and then the ground is cut away to a certain depth, just as a block cutter would do for printing. In some cases the strip of leather is made fast to the roller, and only just covers it; in other cases the leather will be three or four times the circumference of the roller. The distemper graining colour is brushed over the work to be grained, and, while it is wet, the roller, which has previously been damped with a wet chamois leather, is passed over it, and as the roller passes along it takes up the colour in patches of the exact shape of the pattern on the roller used. This is then softened with the badger-hair softener, and overgrained. By a judicious use of these rollers, using only a part of the circumference, and changing the direction, the patterns may be obtained in great variety. The mottle of satinwood, mahogany, ash, and birch is well imitated by these rollers, and also the beautiful feathers or curls in mahogany and satinwood. The mottle of these woods has very little variety, so that one or two patterns suffice for all; and this class of woods is peculiarly suitable for imitation by these rollers. To use the rollers for the imitation of mahogany, satinwood, birch, and maple, lay the colour, mixed in beer, on the surface, pass the roller over it whilst it is wet, soften, and overgrain with a hog-hair overgrainer, previously combed to separate the hair. The roller should occasionally be passed twice over the same place, and in some parts plain spaces left, so as to prevent a repetition of the patterns. Put in the maple eyes by hand in the usual way. Before overgraining the graining should be covered with a coat of turpentine, gold size and a little varnish to bind it, so that the colour may not be removed by the overgraining. For oak, lay the colour on as regular as possible, and comb as in ordinary work, a little common flour paste being added to the water colour, to enable it to stand the comb. Then pass the roller over it, and the badger, in the same direction as the combing. Overgrain same as mahogany, after the application of the mixture of gold size, varnish and turpentine. The rollers must be kept quite clean, and free from grease or oil. Before commencing work wet the rollers thoroughly with a sponge and water, and rub them with a wash-leather or dry cloth, so as to remove any water remaining on the surface. Whilst using the rollers, have a piece of wash-leather at hand, over which they should be frequently passed to keep them quite clean, and prevent the accumulation of colour on their surfaces, which would clog up the pattern. After use wash them well with a brush and water, and let them dry gradually; do not apply heat, as that is likely to crack the surface.

OVERGRAINING.—(*a*) This operation is performed in the same manner

whether the work has been oil grained or spirit grained. In overgraining, watercolours are used; and in order to make them adhere to the underlying graining, whether in spirit or in oil, it is necessary to prepare the work to receive them, otherwise they would run off the surface at once. One method is to rub dry powdered whiting quickly over the surface with a soft rag, removing superfluous powder afterwards, and the grainer can at once finish the work. Another plan, which is principally used when a large piece of work is in hand, is to rub a mixture of fuller's earth and water over the graining, and wait until it is perfectly dry before commencing to overgrain.

Grind Vandyke brown, or burnt umber, in water, and thin with equal proportions of water and beer. The colour should be a trifle darker than the undergraining; a little practice will teach the tints that are best suited to the various woods to be imitated. The colour is applied by a wide hog brush, drawn over the work, generally in the direction of the veins formed by the combing. There are several descriptions of overgraining brushes in use; those most generally employed are thin and flat, with occasional intervals between the tufts of hair. The knots and figures must be lightly touched up with the overgrainer, and the whole gone over quickly with a badger softening brush. The overgraining dries quickly, and the varnish may be then applied, although it is well to wait some hours, so as not to run any risk of removing the graining colour. Sometimes a tolerably strong solution of soda with a little burnt sienna is used for the figures, applying the mixture where these are required, and then washing over the work with a sponge and water. Wherever the soda has been applied, the graining colour will be removed. Go over the whole with a wash made of equal parts of beer and water, and then overgrain, as above described. As a general rule, avoid harsh contrasts between the graining colour and the ground.

(*b*) In the mixing of oil graining colour, it is necessary that the colour should work clean and free. Sometimes the colour will work stiff and dirty, and in this state will not only produce dirty work, but will occupy thrice the time in rubbing in, compared with colour properly mixed. Oil graining colour also requires to be megilped—that is, oil colour alone will not stand when it is combed; the marks made with the comb will all run one into the other, and will thus be obliterated. To prevent this running, the colour requires to be megilped, so that the comb marks will retain the exact form left by the comb. This is accomplished by the use of beeswax, soft soap, hard soap, lime water, whiting, and pure water. When beeswax is used, the best means of dissolving it is to cut the wax into thin shavings or shreds; these are put into a suitable can half filled with pure linseed-oil, into which a red-hot poker is plunged, and stirred well. This will dissolve the wax thoroughly and mix it with the oil. When the wax is all dissolved, the vessel should be filled with either oil or turpentine, which further dilutes and mixes the wax, and serves also to prevent it from congealing, so that it may mix with the graining colour thoroughly. This should be seen to, or else the wax is apt to remain in lumps; and when the colour is spread upon the work, for graining, the wax will be spread unequally, and will not dry in parts, so that it is absolutely necessary that the wax should be thoroughly mixed with the graining colour to produce good work. If soft soap is used, it should first be thoroughly worked up on a palette or a board with either whiting or patent driers; this breaks up the soap, and amalgamates it with the driers, and it will then mix properly with the graining colour. Another method is to break up the soft soap in water to a thick froth or lather; in this state it may be beaten up with water and thoroughly mixed with the oil colour. When the lime water is

used, about 2 lb. of slaked lime should be thoroughly mixed in a pint can full of water, and the lime allowed to settle; a portion of the water may then be added to the graining colour, and the two well stirred together until they are thoroughly amalgamated. If whiting is used, it should be ground in oil, and then mixed with the graining colour. Pure water will also answer the purpose. The wax is the most effectual, but there are some objections to its use. On the whole, pure water is preferable, for if it is well mixed with the oil colour, it megilps it sufficiently to hold the combing until it sets; the water then evaporates and leaves no injurious effects behind, and the projection of the grain is less than it is if any other medium is used.

The most useful colours for mixing oak-graining colour are raw and burnt Turkey umber, Oxford ochre, Vandyke brown, and burnt sienna. The first three, with the addition of ivory black, are all that is required for mixing any shade of graining colour. For light oak or wainscot graining colour, mix $\frac{2}{3}$rds linseed-oil with $\frac{1}{3}$rd turpentine; add a little Oxford ochre and raw Turkey umber in sufficient quantity, according to the shade required and amount of stuff mixed. Terebene or liquid driers should be added, the quantities being regulated, according to whether the graining colour is required to be quick or slow drying. A safe quantity to use, if the liquid drier is of the best quality, is about $\frac{1}{2}$ oz. to a pint of colour. This will cause the colour to dry in about 7 or 8 hours, but twice the quantity may be used with safety if the colour is required to dry very quickly. Sugar of lead ground in oil may be used as a drier for graining colours, but the liquid drier is better. After adding the liquid driers, beat or stir up together; add pure rain water in the proportion of $\frac{1}{2}$ pint of water to 3 pints of oil and turps; beat or stir up until the whole is thoroughly mixed together, after which strain through a fine strainer or a double fold of fine muslin. The colour should be thinned until it works freely and lies on well, so that when the colour is being brushed over the work to be grained, it will lie on evenly, and be easily spread, and will look clean and of one uniform shade of colour. Care and cleanliness of working are necessary to the successful carrying out of this work; and it is essential that the colour, the brushes, and all working tools should be clean to begin with, and be kept clean.

Marbling. — *Black and Gold Marble.*—Ground, deep ivory black. Put on veins of white-lead, yellow ochre, and burnt and raw sienna, with a camel-hair brush. The spaces between the veins must be glazed over with a thin coat of grey or white, over which pass a few white veins. The veins may also be put on with gold leaf. Another method is to have a yellow ground, streaked with broad ribbons of black, in which fine veins are obtained by drawing a sharp piece of wood along them whilst wet, so as to expose the yellow beneath.

Black and White Marble.—White ground, and with dark veins, put on with a marbling crayon, and softened while the ground is wet. Or, when the ground is dry, cover it with a thin coat of white-lead, and put the veins in with a camel-hair pencil. Blend while wet.

Blue and Gold Marble.—Ground, a light blue; when dry, take blue with a small piece of white-lead and some Prussian blue, and dab on in patches, leaving portions of the ground to show between. Blend together with a softener; next put on white veins in every direction, leaving large open spaces to be filled up with a pale yellow or gold paint. Finish with fine white irregular threads.

Dove Marble.—Ground, lead colour, of which it will be necessary to give two or three coats. If the work is new, let it dry hard, rub it smooth with fine glass-paper after each coat, and do not rub the paint off the sharp edges of the wood. For the marbling, take lead colour such as used for the

ground, thin it with turpentine, and rub a light coat over a small part of the work; then with a whitish colour form the small specks or fossil remains. Proceed, piece by piece, till the whole surface is covered, being careful to paint but a small part of the ground at once, so that the colours may have sufficient time to blend together while wet, otherwise the work will appear harsh. Then with a small sash tool, put in faint, broad veins of the thin ground colour, and numerous very fine veins over the whole surface of the work, crossing each other in every direction. Then make the colour a little lighter, by adding white-lead, and with a feather pass over the broad veins in the same direction, forming streams of threads. With thin white, and with a camel-hair pencil go partly over the same vein with short thick touches, following with a fine striping pencil. When the work is hard, it should be smoothed with very fine glass-paper before being varnished. The first layer of veins should be very faint, so as to be scarcely perceptible; for, as the lighter shades are put on, the former veins will appear sunk from the surface of the work, which will give a good effect where the work is exposed to close inspection.

Granite.—(*a*) Grey ground, with white and black spots.

(*b*) Venetian red and white for the ground, with white, black, and vermilion spots.

The spots are put on in several ways; a sponge may be charged with the marbling colour and dabbed on the work, or a common brush may be struck against a stick held a little distance from the work, so as to throw off blots and spots of colour.

Italian Marble.—Ground, a light buff. For marbling, mix stiff in boiled oil white-lead, Oxford ochre, and a little vermilion; grind burnt sienna very fine in boiled oil, and put it into another vessel; mix pure white stiff in oil, and keep this also separate. Thin these colours with turpentine, and have a brush for each. Take the buff brush moderately full of colour, and dab it on in patches, varying as much as possible; take another brush and fill in the spaces between with sienna. With a softener blend the edges together, making them as soft as possible. Draw a few thin white veins over the work with a hair pencil, run in a few thin lines of sienna, and soften.

Jasper.—Mix the ground the same as for mahogany, with red-lead, Venetian red, and a little chrome yellow, thinned with equal parts of oil and turpentine; lake or vermilion may be substituted for the Venetian red, if a brilliant tint is desired. Whilst the ground is wet, dab on some spots of white, soften with a softening brush, and other colours may be applied in the same manner. When dry, put on the veins with a camel-hair brush.

Porphyry.—(*a*) Ground, purple-brown and rose-pink. Grind vermilion and white-lead separately in turpentine, and add a little gold size to each colour to bind it. More turpentine must be added before the colour is applied. When the ground is dry, fill a large brush with vermilion, squeeze out nearly all the colour by scraping the brush on the edge of the palette knife; hold a rod in the left hand, strike the handle of the brush against it, so as to throw small red spots on to the work till the surface is covered. Make the colour lighter by adding white-lead, and use as before. Then with clear thin white throw on very fine spots, and when dry put in a few white veins across the work. This marble may be imitated in distemper in precisely the same manner as in oil.

(*b*) The ground is Venetian red, with a little vermilion and white. For marbling, add a little more white to the ground colour, and sprinkle over the first coat. When dry, repeat the splashing with a mixture of Venetian red and vermilion, and then with white in very fine spots. Form opaque white veins across the work, and transparent threads in various directions. This must be done when the work is dry and hard, with a sable pencil, and the

threads drawn with a feather. For each separate colour use a different brush.

Sienna Marble.—(*a*) Ground, Oxford ochre and white-lead. Use burnt and raw sienna, white, black, and a little lake, for marbling. These colours should be laid on as a transparent glaze, and marked and softened while wet. The colours should be properly softened with a badger brush.

(*b*) Ground, raw sienna or yellow ochre. When dry, mix raw sienna with white-lead, have ready also some white paint, put in broad transparent tints of white and yellow, and while wet blend them together with a softener. Mix Venetian red and a little black, and put in some broad veins in the same direction as the patchy tints run; for the darker veins take a mixture of Venetian red, lake, and black, and draw them over the first layer of veins with a feather, in fine threads, running to a centre, and in transparent veins in different directions. Mix some Prussian blue and lake, and put in the darkest and finest veins over those before laid on. Put in a few touches of burnt sienna between the fine veins, which are formed into small masses. All the colours should be ground in spirit of turpentine, and mixed with sufficient gold size to bind them.

Verde Antique.—If the work is new, lay on a coat of dark lead oil colour. When dry, smooth with glass-paper, and lay on a coat of black paint. When the ground is dry, mix some white-lead with water and a little beer. Lay this on in large streaks. Fill up the spaces left with veins of lampblack, finely ground in beer, thus covering the whole surface of the work. While still wet, soften with a badger-hair brush, so as to cause the veins to run into one another. On the darkest parts of the work lay dabs of white, carelessly applied, to imitate fossils, and dab over the light parts of the work with the black colour for the same purpose. With a thin flat graining brush, or a feather, dipped in the white, form small veins over the black; a few dark blue wavy veins may also be put on. When dry, glaze with a thin coat of raw sienna and Prussian blue, ground in spirit of turpentine and mixed in copal varnish. A little emerald green added here and there heightens the effect.

Verde Antique, Oriental.—Lay on a ground of black in oil. Mix white-lead in oil, thinned with turpentine for the graining colour. Lay this on in broad transparent veins of irregular depth of colour, and whilst wet dab it over with a piece of wash-leather in different parts to imitate fossils; then with a small piece of cork, twisted round on the work between the finger and thumb, produce a number of little spiral figures of various sizes and shapes. Cut notches on the top of a feather, dip it in the white, and pass it over the black ground in zigzag and fantastic veins, with occasional sharp angles. Let all the work get quite dry, and then glaze with green, in some parts with Prussian blue, in others with raw sienna, leaving some portions untouched. When dry, wash with beer, dip a feather into the whiting ground, and draw fine veins. To finish, give a coat of glaze, made of a little Prussian blue and raw sienna, mixed in equal parts of boiled oil and turpentine, leaving some of the white veins unglazed.

Mixing Oil Colours for Tints.—*Bright Blue.*—2 parts cobalt blue, 40 parts zinc-white.

Deep Blue.—2 parts Prussian blue, 30 parts white-lead.

Blue grass.—2 parts Prussian blue, 4 parts Paris green, 14 parts white-lead.

French Blue.—10 parts cobalt, 4 parts zinc-white.

Green Blue.—6 parts ultramarine blue, 10 parts lemon chrome, 200 parts white-lead.

Hazy Blue.—2 parts burnt sienna, 30 parts ultramarine blue, 100 parts white-lead.

Mineral Blue.—1 part red madder lake, 2 parts cobalt blue, 3 parts white-lead, add a little ivory or drop black to get most suitable shade.

Azure Blue.—2 parts ultramarine blue, 100 parts white-lead.

Blue Grey.—6 parts Prussian blue, 2 parts lampblack, 200 parts white-lead.

Royal Blue.—1 part Prussian blue, 9 parts ultramarine. White-lead or zinc-white may be added to lighten this as required.

Brilliant Green.—2 parts light chrome green, 18 parts emerald green.

Bronze Green, dark.—2 parts dark orange chrome, 4 parts chrome yellow, 30 parts drop black.

Bronze Green, medium.—10 parts chrome yellow, 6 parts burnt turkey umber, 2 parts lampblack.

Bronze Green, light.—4 parts chrome yellow, 12 parts raw turkey umber.

Bottle Green.—10 parts medium chrome green, 2 parts drop black.

Emerald Green.—Is used as ordinarily prepared and sold.

Fern Green.—10 parts lemon chrome, 2 parts light chrome green, 2 parts drop black.

Foliage Green.—6 parts medium chrome green, 1 part drop black.

Olive Green.—14 parts light golden ochre, 2 parts drop black.

Another Olive.—18 parts French ochre, 2 parts raw umber.

Amber Yellow.—6 parts burnt sienna, 14 parts burnt umber, 20 parts chrome yellow.

Canary Yellow.—4 parts permanent yellow, 2 parts lemon chrome, 10 parts white-lead.

Golden Yellow.—20 parts lemon chrome, 6 parts orange chrome, 10 parts white-lead.

Brimstone Yellow.—2 parts lemon chrome, 2 parts permanent yellow, 6 parts white-lead.

Golden Orange.—1 part of light golden ochre, and 1 part dry orange colour.

Golden Ochre.—2 parts chrome yellow, and 30 parts French yellow ochre.

Dark Golden Ochre.—20 parts Oxford ochre, 2 parts orange chrome.

Golden Russet.—2 parts light Venetian red, 10 parts lemon chrome.

Turkey Red.—Venetian red and red oxide.

Tuscan Red.—18 parts Indian red, 2 parts rose pink.

Brilliant Tuscan Red.—8 parts Indian red, 2 parts red madder lake.

Oriental Red.—4 parts Indian red, 2 parts white-lead.

Flesh Colour.—2 parts deep vermilion, 40 parts French ochre.

Cherry Red.—1 part vermilion, 1 part carmine.

Citron.—6 parts chrome yellow, 4 parts raw umber.

Another Citron.—4 parts French chrome, 2 parts burnt sienna, 12 parts burnt Turkey umber.

Foliage Brown.—1 part orange chrome, 1 part Vandyke brown.

Indian Brown.—1 part French ochre, 1 part lampblack, 1 part light Indian red.

Maroon, light.—10 parts dark Venetian red, 1 part drop black.

Maroon, dark.—20 parts dark Indian red, 1 part lampblack.

Orange Brown.—1 part orange chrome, 1 part burnt sienna.

Seal Brown.—4 parts light golden ochre, 2 parts burnt sienna, 20 parts burnt umber.

Snuff Brown.—1 part golden ochre, 1 part burnt umber.

Terra Cotta.—2 parts burnt sienna, 4 parts white-lead.

Another Terra Cotta.—4 parts French ochre, 2 parts Venetian red.

Roman Ochre.—2 parts burnt sienna, 2 parts burnt umber, 50 parts French ochre.

Purple.—2 parts ultramarine blue, 4 parts rose pink.

Violet.—6 parts ultramarine blue, 4 parts rose lake, 2 parts ivory black.

Purple Brown.—2 parts ultramarine blue, 2 parts lampblack, 10 parts Indian red.

Purple Black.—2 parts rose pink, 6 parts lampblack.

Blue Black.—20 parts lampblack, 2 parts Prussian blue.

Dove.—Ultramarine blue, Indian red, lampblack, white-lead.

Pearl.—White-lead with a little best lake or blue.

Light Pine.—Umber, spruce ochre, yellow ochre, white-lead.

Claret.—Venetian red and black.

Stone.—4 parts burnt umber, 8 parts medium chrome, 20 parts white-lead.

Brown Stone.—2 parts burnt sienna, 4 parts dark golden ochre, 36 parts burnt umber.

Salmon.—Venetian red and white-lead.

Wine-Colour.—Vermilion, carmine, ultramarine, and a little ivory black.

Lilac.—Vermilion, ultramarine, white-lead.

Buff.—Yellow ochre and white-lead, a little Venetian red may be added.

Plum.—Carmine, ultramarine blue, white-lead, ivory black. For various shades, omit the black and increase the white-lead.

Leather.—French yellow, burnt umber and Venetian red.

Fawn.—Stone ochre, vermilion, and white-lead.

Lavender.—Carmine, ultramarine blue, ivory black, white-lead.

Slate.—Raw umber, ultramarine blue, lampblack, and white-lead.

Gold Size. *For Gilding.*—1 gal. of linseed-oil, 4 lb. gum copal, boiled together until they "string." Then add 3 gal. of boiling oil. When cool enough add turpentine to the required consistence. This does not dry so quickly as japanners' gold size.

Japanners' Gold Size.—2 gal. boiled linseed-oil, 17 lb. gum kowrie, 3 lb. litharge, 3 gal. turpentine. Proceed as with the foregoing recipe.

Brunswick Black.—A quality suited for cheap work is made of 20 lb. common asphaltum, 20 lb. black pitch (known as bone pitch), 2¼ lb. of lampblack, 5 gal. boiled linseed-oil, 2¼ lb. litharge, 2¼ lb. black oxide of manganese, and 15 gal. turpentine.

A better quality is made up of 40 lb. asphaltum, 5 gal. boiled linseed-oil, 2¼ lb. litharge, 2¼ lb. black oxide of manganese, and 20 gal. of turpentine.

Another fair quality consists of 14 lb. asphaltum, 14 lb. pitch, 4 gal. boiled linseed-oil, 5 lb. litharge, 5 lb. red-lead, and sufficient turpentine to thin it.

The process is to melt the asphaltum and pitch in an iron pot, letting it boil several hours, stirring occasionally, to ensure all moisture being driven out (this is essential for best results). The oil is then added and the dry ingredients sprinked in gradually. The boiling is continued for an hour or two longer and then the pot is removed from the fire and allowed to cool. When it is about 250° to 220° stir in the turpentine. It is not safe to do this when it is much hotter, nor anywhere near the fire.

Berlin Black.—¼ cwt. asphaltum, ½ gal. boiled linseed-oil, 7 gal. turpentine. Proceed as last. This is a good quality black. The addition of terebene, in same quantity as the oil, makes what is known as Black Japan.

Carriage Painting.—The following is the substance of an address delivered by McKeon, secretary and treasurer of the Master Car-Painters' Association, of the United States: A first-class railway coach costs, when complete, about 1200*l.* To protect this work, the painter expends 60*l.* to 120*l.* The latter figure will make a first-class job. The car has been completed in the wood-shop, and is turned over to the painter, who is responsible for the finish. He is expected to smooth over all rough places or defects in the wood, which requires both patience and skill to make the work look well. Twelve weeks should be the time allowed to paint a car, and it cannot be done in any less time, to make a good job that will be a credit to the painter and all other parties interested in the construction and finish of the car. Too much painting is done in a hurry; proper time is not given the work to dry or become thoroughly hardened before it is run out of the shop, and consequently it does not always give the satisfaction it should; nor can it be expected that hurried work will be so lasting or durable as that which has the necessary time given to finish it.

Priming Paint.—The priming coat

of paint on a car is of as much importance as any succeeding one, and perhaps more. Good work is ruined in the priming by little or no attention being given by the painter to the mixing and application of the first coat. The foundation is the support, and on that rests success or failure. The priming should be made of the proper material, mixed with care from good lead and good oil, and not picked up from old paints, which have been standing mixed, and must necessarily be fat and gummy, for such are unfit for use on a good job, and will have a decided tendency to spoil the whole work. Special care should be exercised, both in mixing and applying the priming, and it should be put on very light, so that it may penetrate well into the wood. Too much oil is worse than not enough. Good ground lead is by far the best material for the under-coats on a car. Two coats should be given to the car before it is puttied, as it is best to fill well with paint the nail holes and plugs, as well as defects in the wood, so that moisture may not secure a lodgment, which otherwise will cause the putty to swell, although sometimes unseasoned lumber will swell the putty; and as it shrinks, the nail remains stationary, and of course the putty must give way.

In mixing putty, which may be a small matter with some, take care to so prepare it that it will dry perfectly hard in 18 hours. Use ground lead and japan, stiffening up with dry lead, and whatever colouring you may require in it to match your priming coats.

The next coats, after the work is well puttied, should be made to dry flat and hard. Two coats should be applied, and, for all ordinary jobs or cheap work, sandpapering is all that is necessary for each coat; but when a good surface is required, I would recommend one coat to be put on heavy enough to fill the grain; and before being set, scrape with a steel scraper. The plain surface is all that requires coating and scraping with the heavy mixture. For this coat, which is called filling, use one half ground lead and any good mineral which experience has shown can be relied on. This scraping of the panel work will fill the wood equal to two coats of rough-stuff, and saves a great amount of labour over the old process, when so much rubbing with lump pumice was done. Sandpaper when the filling is thoroughly hard, and apply another coat of paint of ordinary thickness, when, after another sandpapering, you have a good surface for your colour.

Rough-coating on cars has gone almost out of use, and few shops are now using it to any extent. My experience is that paint has less tendency to crack where rough-stuff is left off. I do not claim that the filling was the principal cause of the cracking, if it was properly mixed; but I believe the water used in rubbing down a car with the lump pumice injures the paint, as it will penetrate in some places, particularly around the moulding plugs.

Finishing Colour.—The car being ready for the finishing colour, this should be mixed with the same proportion of drier as the previous coat, or just sufficient to have it dry in about the same time. A great error with many car-painters is using a large portion of oil in the under-coats, and then but little, if any, in the finishing coats: this has a decided tendency to crack, the under-coats being more elastic. Always aim to have colour dry in about the same time, after you have done your priming; by this plan you secure what all painters should labour to accomplish—namely, little liability to crack. Work will of course crack sometimes, after being out a few months, or when it has repeated coatings of varnish; and using a quick rubbing-varnish on work will cause it to give way in fine checks quicker than anything else. Many of the varnishes used are the cause of the paint cracking, and no painter has been wholly exempt from this trouble.

Cause of Cracking.—The most common cause of cracking is poor japan,

which is the worst enemy that the car-painter has to contend with. The greater part of the japan is too elastic, and will dry with a tack, and the japan gold size has generally the same fault, although the English gold size is generally of good quality; but its high price is an objection to its use. A little more care in the manufacture of japans would give a better drier, and few would object to the additional cost. Japan frequently curdles in the paint; it will not mix with it, but gathers in small gummy particles on the top. Work painted with such material cannot do otherwise than crack and scale, and the remedy lies only in getting a good pure article of turpentine japan.

In regard to using ground lead, car-painters differ, as some prefer to grind their own in the shop. I use the manufactured lead, and my reasons for doing so are that it is generally finer than any shop can grind it with present facilities, and it has age after grinding, which improves its quality. You can also get a purer lead and one with more body than you can by grinding in the shop, which is a fact that I think most painters must admit. I have tested it very fully, and am convinced on this point.

Mixing the Paints.—Permit me to make a few suggestions here in regard to the mixing of paint, which may not fully agree with others' views. There is just as much paint that cracks by putting it on too flat as by using too much oil. Some painters mix their finishing colour so that it is impossible to get over a panel of ordinary size before it is set under the brush, and consequently the colour will rough up. Colour should be mixed up so that it will not flat down for some time after leaving it, and then you have got some substance that will not absorb the varnish as fast as it is applied to the surface. This quick drying of colour is not always caused by want of oil in it, but because there is too much japan, and a less quantity of the latter will do better work, and make a smoother finish. Give your colour 48 hours to dry between coats; always give that time, unless it is a hurried job, and experience has fully demonstrated that it is poor economy to hurry work out of the shop before it is properly finished.

Oils, Driers, and Colours.—In car-painting, both raw and boiled oils are used, and good work may be done with either, but I recommend oil that is but slightly boiled, in preference to either the raw or the boiled. After it is boiled, if it is done in the shop, let it stand 24 hours to settle, then strain off carefully; this takes out all the impurities and fatty matter from the oil, and it will dry much better, nor will it have that tack after drying that you find with common boiled oil. Use the proper quantity of drier in mixing your paint, and a good reliable job will be the result. In car-painting, never use prepared colours which are ground in oil, as nine-tenths of such colours are ground in a very inferior oil, and they may have been put up for a great length of time, in which case they become fatty, and will invariably crack. These canned colours do not improve with age, as lead and varnish do. Finishing colours should all be ground in the shop, unless special arrangements can be made with manufacturers to prepare them; and the colour should be fresh, not over 6 or 8 days old after being mixed and open to the air. Enough may be prepared at a time to complete the coating on a job; but when colour stands over a week, it is not fit to use on first-class work, as it becomes lifeless and has lost that free working which we find in freshly mixed colours. Such colour may, however, be used upon a cheap class of work, or on trucks, steps, etc., so that nothing need be wasted in the shop.

Varnishing.—Three coats of varnish over the colour are necessary on a first-class coach. The first coat should be a hard drying varnish put on the flat colour; the quick rubbing that some use I would not recommend, but one that will dry in 5 days (in good drying weather) sufficiently hard to rub, is the

best for durability. After striping and ornamenting the car, and when thoroughly washed, give a coat of medium drying varnish. Let this stand 8 days; then rub lightly with curled hair or fine pumice, and apply the finishing coat, which is "wearing body;" this will dry hard in about 10 days, after which the car may be run out of the shop. It should then be washed with cold water and a soft brush, and is ready for the road. In varnishing, many will apply the varnish as heavy as they can possibly make it lie, when, as a consequence, it flows over and runs or sags down in ridges, and of course does not harden properly; this also leaves a substance for the weather to act on. It is better to get just enough on at a coat to make a good even coating which will flow out smooth, and this will dry hard, and will certainly wear better than the coat that is piled on heavily.

Varnishing, we claim, can be overdone, some painters' opinions to the contrary. We have heard of those who put 2½ gal. on the body of a fifty-foot car at one application, and we have also listened to the declaration, made by a member of the craft, that he put 2 gal. on the body of a locomotive tank. Such things are perhaps possible, and may have been done; but if so, we know that the work never stood as well as it would if done with one-half the quantity to a coat. In varnishing a car, care should be taken to have the surface clean; water never injures paint where it is used for washing; and a proper attention to cleanliness in this respect, and in the care of brushes used for varnishing, will ensure a good-looking job.

Perhaps your shop facilities for doing work are none of the best, but do the best you can with what you have. Select, if possible, a still, dry day for varnishing, especially for the finishing coat. Keep your shop at an even temperature; avoid cold draughts on the car from doors and windows; wet the floor only just sufficient to lay the dust, for if too wet, the dampness arising will have a tendency to destroy the lustre of your varnish. Of course we cannot always do varnishing to our perfect satisfaction, especially when there are 25 or 30 men at work in an open shop, and 6 or 8 cars are being painted, when more or less dirt and dust are sure to get on the work.

A suggestion might here be made to railroad managers, which is that no paint-shop is complete where the entire process of painting and finishing a car is to be done in one open shop. A paint-shop should be made to shut off in sections by sliding doors, one part of the shop being used exclusively for striping and varnishing.

Importance of Washing Vehicles.—In regard to the care of a car after it has left the shop more attention should be given to this than is done on many roads. The car should not be allowed to run until it is past remedy, and the dirt and smoke become imbedded in the varnish, actually forming a part of the coating, so that when you undertake to clean the car you must use soda or soap strong enough to cut the varnish before you succeed in removing the dirt. Cars should be washed well with a brush and water at the end of every trip. This only will obviate the difficulty, and these repeated washings will harden the varnish as well as increase its lustre. We know that, in washing a car, where soap is required to remove the dirt and smoke, it is almost impossible to get the smoke washed off clean; and if it is not quite impossible, the hot sun and rain will act on the varnish and very soon destroy it.

Re-varnishing. — Cars should be taken in and re-varnished at least once in 12 months; and if done once in 8 months, it is better for them, and they will require only one coat; but where they run a year, they will generally need two coats. Those varnished during the hot months will not stand as well as if done at any other time. Painting done in extremely cold weather, or in a cold shop, is more liable to crack than if done in warm weather.

How to Dry Paint.—Paint dried in the shop, where there is a draught of dry air passing through, will stand better than that dried by artificial heat; and you will find, by giving it your attention, that work which has failed to stand, and which cracked or scaled, was invariably painted in the winter season or in damp, cold weather. I have paid some attention to this matter, and know the result.

Cement Paint for Carton-pierre.—Composed of 2 parts washed graphite, 2 red-lead, 16 freshly-prepared cement, 16 barium sulphate, 4 lead protoxide, 2 alcoholised white litharge. The paint must be put on as soon as the roofing is securely fastened, choosing the dry season and a sunny day. Care must be taken to put it on well over the joints; it is recommended that an extra coating should be given to the portions that overlap each other, so as to render them watertight. As a rule, two coats are put on. The first, whilst still wet, is covered with an even layer of fine dry sand sprinkled over it through a sieve. This is done bit by bit, as the roof is painted, so as to prevent the workmen stepping on the wet paint. The second coat is put on about a week later, the sand which has not stuck fast being first swept off. The second coat is not sanded. It is merely intended to combine with the under-coat and form a durable waterproof surface, which will prevent the evaporation of the tar-oil, the usual cause of the failure of carton-pierre roofing, and present a good appearance as well. (Mack.)

Enamel Painting. — (*a*) For fancy woodwork, such as bric-à-brac, also for interior decorative work the enamel made of copal varnish, gold size and turpentine gives much the best results. This will give a permanently hard and glossy surface. The palest varnish, which is the most expensive, need not be used for dark or dull colours. It is important to remember that most enamel paints have no good covering qualities of themselves. The article or surface must be given one or two coats of ordinary oil paint and be well rubbed down with sand-paper or pumice-stone. The enamel paint must be considered more as a coloured varnish.

In dealing with new work, such as doors and skirtings, which are usually done in white, the woodwork is first sandpapered, knotted, and stopped with white-lead putty, then given two coats of white-lead mixed to a working consistence with equal parts of raw linseed-oil and turpentine and a little patent driers. Each coat should be thoroughly rubbed down or flatted, in order to remove any inequalities, until the work assumes a solid appearance. The work is then given a coat of zinc-white mixed with 2 parts of pale boiled oil and 1 part turpentine, with a little patent driers, allowing good time to harden. Rub lightly over with No. 0 sandpaper, dust well, and apply a coat of finishing white enamel. The finish depends very much on the preparation of the ground. For some classes of decoration, six or eight coats are given before the enamel is applied, the first coat of enamel being sometimes flatted the second being the finishing coat.

Enamelling Furniture.—In dealing with furniture, to get good results, considerable patience and care are necessary. The work will not stand any hurry, but must go through its regular course and have proper time to harden between each coat and process, and the rubbing down must be done patiently and gently. Heavy pressure will defeat the desired end. There are several kinds of fillers on the market, most of them being of a dark colour, and not suitable for white work, on account of so many coats of paint being required. It is always best to fill up with the same tint of colour you intend to finish with, then it can be rubbed down without becoming shady. The tools and material required are as follows: Several daubers made of cotton wool and covered with silk or linen—silk preferred; several flat wooden blocks of various sizes and forms, made suitable for getting into

the corners and rubbing down the mouldings. These must be covered with pieces of felt, half an inch thick, and then with silk upon the side intended for use; a good close Turkish sponge and some chamois skin. Next some best white-lead ground in oil, a good clean, hard drying varnish, such as copal; some white enamel varnish, some lump pumice-stone free from grit and hard particles, some pumice-powder medium fine, some putty-powder and rotten-stone. To make these instructions easily understood, we will take a flat panel of wood to work upon, the wood being new. Give it two coats of ordinary white oil paint, or a coat of glue and whiting, mixed to the consistence of paint, laid on smoothly with the sponge or a brush, the way of the grain. Allow it to thoroughly harden. Now mix some white-lead with sufficient varnish to bind it, thin down to the proper consistence with turpentine. Give the panel four or five coats of this, allowing each coat to thoroughly dry before applying the next. When the same is thoroughly hardened, rub down with the lump-pumice and water, taking off the rough parts; next use the felt and pumice-powder, working in a circular manner. Do not press hard. Do it gently, as it will go into hollows. Great care must be taken to get it to a level surface, without scratches. Should it get scratched or uneven, give it one or two more coats, laying them on as evenly and smoothly as possible; then rub down again. When properly done it will be perfectly smooth, level, and free from scratches. It is now ready to have the finishing coats. Take some tube flake-white mixed in oil, and thin to the consistency of cream with copal varnish. Give one coat, and allow to thoroughly dry; then give another, but add more varnish to it. Now let this dry hard. The time it will take will be according to the drying quality of the varnish—generally a week to ten days. Anyway, it is best to let it stand as long as possible before polishing, as the harder it is the brighter and more durable will be the polish. The final polish will be given with the putty-powder, and then the rotten-stone. The putty-powder is used with water and the rubbers; the rotten-stone mixed with alcohol and water—two of alcohol to one of water. It is first applied with clean rubbers and felt, and lastly with the heel of the hand. Any decoration can be put on, either with a stencil or free hand. The colour should be mixed with some varnish. ('The Art Amateur.')

Another method is to work with spirit varnish and obtain a french-polish finish as follows. Mix gilder's washed whiting in a warm solution of double size, and apply like paint. When dry, remove any apparent roughness by glasspapering; then apply a second coating. This, when dry, must be smoothed down with a felt-covered rubber and pumice-stone powder. Then dissolve 2 oz. of isinglass in 1 pint of water, and stir in 3 oz. of flake-white. Apply as hot as possible, but avoid working it about so much as to break up the size foundation. If necessary, rub down smooth with felt and pumice, and repeat the process as often as may be required to gain a solid white surface. When dry, apply white or transparent polish, dipping the rubber occasionally into some flake-white before enclosing it in the rag covering. On some kinds of wood it will be found serviceable to apply one or more coats of white hard spirit varnish, to assist in gaining a good body more quickly. For this purpose, mix flake-white in the varnish also. A good body of polish, or combination of polish and varnish, having been built up, and its sinking and hardening allowed for, can be finished off the same as any ordinary polished surface.

High-grade finish is worked up by a process more akin to house-painters' work. Soft varieties of wood are coated with size and whiting or a good brand of grain-filler. Several applications of white paint are then given. The paint used does not contain much

oil, preference being given to the addition of varnish to act as a binder. As each coat dries, it is smoothed down with pumice till a surface is built up perfectly smooth and free from scratches. For white coburg, white enamel varnish is used, or the finest brand of copal varnish, tinted by adding flake-white, as supplied in tubes, two coats of this being given. If the garish appearance of the varnish is objected to, it may be polished by hand. The work of enamelling may, however, be much simplified by the use of specially prepared enamels, laid on the foundation of double size and washed whiting. Flake-white gives far better results than white-lead.

It is useless to attempt this mode of finish on goods that have been already polished unless the surface has been thoroughly cleaned, either by the aid of scrapers or a good polish solvent. Furniture that is finished in self-colour enamels is generally of quaint design of simple construction, the sameness of colour being sometimes relieved by suitable decorative designs in subdued colourings. The enamel surface may be worked up to several degrees of finish, according to the class of goods. High-grade work is finished in best enamel, which costs about 20*s*. per gallon, whilst the cheaper grades are finished by a combination of french-polishing and spirit varnish. In either case, the foundation colour and finishing coats should be laid on with brushes that have been previously used on other work. If new brushes are used, there is great risk of trouble through the shedding of bristles or hairs, or the surface may be spoiled by brush marks. (*Hasluck.*)

(*b*) The gloss of enamel paints is due to varnish. Good enamel paint has copal varnish (of good quality) with turpentine (American). To this may be added gold size for quick drying.

In other words it is varnish and turpentine for slow drying work and the greatest elasticity; and varnish, turpentine and gold size for quick drying. The latter is not actually brittle but is less elastic than the other.

For slow-drying enamel take 3 parts copal varnish with 1 part turpentine.

For quick-drying enamel, 4 parts of copal varnish with 1 to 4 parts gold size and 1 part turpentine (or as much turpentine as is required to thin the paint when the colouring body is added).

Bath Enamel.—The above enamel, with gold size, is best; or the following is a special preparation. Prepare Crystal Varnish by dissolving 6 lb. gum damar in 1 gal. of turpentine. This takes about 24 hours to prepare, the mixture being frequently agitated or churned. After this it is strained and allowed to settle and clear. To 1 part of this varnish add 1 part gold size. It makes a cheaper enamel than the use of copal varnish if made in large quantities.

The foregoing are clear fluids, and require colour bodies as follows. The quantities are approximately 6 lb. to 10 lb. of body to the gallon of varnish mixture. Although mentioned further on, it may be stated here that enamel paints have not all good covering qualities, and in every case a groundwork of oil paint or some foundation of the kind is required. The enamel paint is to give brilliancy of colour and glossy finish.

Pure White.—Use zinc-white ground in oil, with either of the varnish preparations given. For a pure white, the varnish should be as pale as possible, and of the highest quality. As a rule, white enamel, if good, is the most expensive of any. A very little blue may be added if desired.

Ordinary White.—White-lead.

French White.—White-lead, vermilion, and chrome.

Pearl.—White-lead, Prussian blue, and lampblack.

Flesh.—White-lead and vermilion, or white-lead and crimson lake.

Leather.—Burnt umber, French yellow, Venetian red.

Light Yellow.—White-lead and French yellow.

Dark Yellow.—French yellow with a little red-lead.

Orange.—French yellow and orange lead, or French yellow and red-lead.

Old Gold.—White-lead, medium chrome, French ochre, and a little umber.

Gold.—White-lead, chrome yellow, and burnt sienna.

Rich Gold.—White-lead, French ochre, and a little vermilion.

Primrose.—White-lead and chrome yellow.

Lemon.—Chrome yellow, adding white-lead if necessary.

Yellow Lake.—White-lead, umber, scarlet lake, Naples yellow; about equal parts.

Terra Cotta.—White-lead, brown, Venetian red.

Russet.—White-lead, chrome green, orange chrome, and raw umber.

Robin's Egg.—White-lead, chrome green, and ultramarine.

Olive.—Prussian blue, lampblack, and lemon chrome (chiefly the latter).

Leaf Bud.—White-lead, chrome green, orange chrome.

Bottle Green.—Prussian blue, lemon chrome, and lampblack.

Apple Green.—White-lead, orange chrome, chrome green.

Willow Green.—White-lead, chrome green, burnt umber.

Ordinary Greens.—Various shades are obtained with white-lead, yellow-ochre, and indigo.

Pea Green.—White-lead, Prussian blue, chrome yellow.

Myrtle Green.—White-lead, dark chrome green, and ultramarine.

Grey Green.—White-lead, ultramarine blue, lemon chrome, lampblack.

Claret.—Ultramarine, vermilion, carmine, and a little ivory black.

Carnation.—Vermilion, carmine, and a little white-lead.

Deep Red.—Vermilion and red-lead.

Dark Red.—Red-lead and Venetian red.

Scarlet.—Light vermilion, or scarlet red.

Crimson.—Dark vermilion and a little carmine.

Peach Blossom.—White-lead with a small quantity of orpiment.

Salmon.—White-lead and Venetian red.

Shrimp Red.—White-lead, Venetian red, burnt sienna, and a little vermilion.

Rose Pink.—Zinc-white and carmine; or white-lead and carmine.

Post Office Red.—White-lead, red-lead, and Venetian red.

Brick Red.—White-lead, 1 part; yellow ochre, 2 parts; Venetian red, 2 parts.

Poppy.—White-lead, red-lead, and Venetian red.

Plum.—White-lead (a little), ultramarine, carmine, and drop black.

Violet.—White-lead, Prussian blue, vermilion, and lampblack.

Lilac.—White-lead, vermilion, and ultramarine.

Magenta.—Ultramarine, carmine, and vermilion.

Lavender.—The same as lilac, or carmine may be used instead of vermilion.

Purple.—White-lead, Prussian blue, and vermilion.

Amber Brown.—White-lead, burnt umber, burnt sienna, orange chrome, and lampblack.

Snuff Brown.—Burnt umber, yellow ochre, and a little Venetian red.

Maroon.—Orange chrome, carmine and ivory black.

Fawn.—White-lead, stone ochre, and vermilion.

Light Buff.—White-lead and French ochre.

Dark Buff.—White-lead, French ochre, and Venetian red.

Purple Brown.—White-lead (a little), ultramarine blue, Indian red, and lampblack.

Chestnut.—Red ochre and lampblack. This can be heightened with yellow ochre.

Light Stone.—White-lead, Venetian red, and raw umber.

Olive Brown.—Lemon yellow and burnt umber.

Citron.—White-lead, chrome yellow, Prussian blue, and Venetian red.

Ordinary Browns.—Several shades

can be produced by mixing white-lead, light red, and indigo.

Tan.—White-lead, burnt sienna, and lampblack.

Golden Brown.—White-lead, French ochre, chrome yellow, and lampblack.

Smoke.—Ultramarine blue, yellow ochre, lampblack, and white-lead

Lead Colour.—About 2 parts of white paint with 1 part black.

Slate.—White-lead, raw umber, blue, and lampblack.

Brown Stone.—White-lead, orange chrome, Tuscan red, and lampblack.

Light Oak.—White-lead, French ochre, and Venetian red.

Cerulean Blue.—White lead and ultramarine blue.

Lake Blue.—White-lead and Prussian blue.

Electric Blue.—White-lead, ultramarine blue, and a little raw sienna.

Azure.—White-lead and Prussian blue.

Peacock Blue.—White-lead, Prussian blue, chrome green; or white-lead, cobalt blue, and Chinese blue.

Fresco Painting.—The preparation of a wall for fresco painting is a matter of time, and should be executed with much carefulness, for on the goodness of this portion of the work depends in a great measure the durability of the painting. If the wall is already covered with plaster or laths, it should be cleared, the bricks thoroughly scraped, and afterwards well chipped. See that the bricks are in good condition and perfectly dry, and then proceed to lay on the first coat, consisting of river sand and the best old lime, mixed to about the usual thickness. This should be laid on so as to leave a level but rough surface. At some places on the Continent small flint pebbles are mixed with this composition to give the requisite roughness. This ground-work should be allowed to dry thoroughly; indeed, unless the lime is old, it will be some considerable time before it will be safe to put on the intonaco or painting-surface. This should be prepared with the very best old lime, perfectly free from grit. The lime is mixed in troughs to the consistence of milk, and is then passed through hair sieves into jars, where it is allowed to settle, and the water is poured off. It is then ready to be mixed with the sand (fine quartz sand, well sifted, is the best) in the proportion of one part lime to two parts sand. The implements used to float on the last coat are made of wood or glass, but trowels of iron may be used if free from rust, and care is taken not to press the iron too forcibly on the intonaco. When the lime and sand second coating is ready, the first rough coat must be wetted thoroughly, and the intonaco floated on in two coats, the last with rather more sand than the first. The thickness of the two should be about $\frac{3}{16}$ inch. After these are spread, go over the whole with a roll of wet linen, which will remove the marks of the trowel, and prevent the surface being too smooth. While the ground is being prepared, a cartoon or drawing on paper is made of the subject, executed with a correct outline and with the wished-for effect properly shown. When the finished cartoon is made the same size as the painting, it is usually executed in black and white with ink or crayons, but it is also necessary to have a study of the subject in colours, and this is generally done on a small scale. The pigments used are mostly minerals, and are ground and applied with pure water. With the surface of the wall still wet but firm and smooth, the tracing is laid over the portion prepared, and the lines of the cartoon are slightly indented on the plaster with a blunt point; or the lines have small holes in them pierced at certain intervals, and the design thus pricked out is laid upon the surface and dusted with a pounce-bag containing fine dry powder, and thus the outline is repeated on the ground by the dots of powder which have passed through the minute holes. When the intonaco has become firm enough to just bear the pressure of the finger, the first washes of colour may be put on. If the paints

ing is intended to be large, only sufficient plaster is put on to serve for the part which can be accomplished in the time at the disposal of the painter, usually enough only for a day's work, and this portion should end at the edges of some bold outiine, as flowing drapery, a pillar, and so on. A difficulty in fresco painting is that the colours become much lighter after the plaster dries, and for this allowance must be made; however by practice the painter may overcome this difficulty, and can test the difference between the colour as wet and as dry by putting a touch upon a piece of umber, which instantly dries the colour and shows it as it will be when the intonaco has dried.

Iron Paint.—The 'Photographisches Wochenblatt' mentions that Spangenberger has a paint composed of pulverised iron and linseed-oil varnish. It is intended for painting damp walls, kettles, outer walls, or any place or vessel exposed to the action of the open air and weather. Should the article be exposed to frequent changes of temperature, linseed-oil varnish and amber varnish should be mixed with the paint intended for the first 2 coats, without the addition of any artificial drying medium. The first coat should be applied rather thin, the second a little thicker, and the last in a rather fluid state. It is not necessary to free iron from rust, grease, &c., by means of acid before applying the paint, as a superficial cleaning is sufficient. The paint is equally adapted as a weather-proof coating for iron, wood, and stone.

Miscellaneous Paints.—*Gold Paint.*—Mix a quantity of gold leaf, a little honey, sugar candy, gum arabic, and water, to the consistence of jelly.

Another Method.— Have gold (or bronze) powder and first write out the letters or design in gold size. When the size has dried to a sticky degree, called "tacky," dust the gold on with a soft sable brush, holding a sheet of writing paper beneath, if it is perpendicular work.

Using Gold Leaf.—Write out the letters or design in gold size, and, when "tacky," apply the gold leaf with a gilder's tip. Press down with cotton wool. Do not clean off superfluous gold until dry.

Gold Lettering on Glass.—Write out the lettering or design with a thin coat of isinglass size and proceed as with the last recipe.

Imitation Gold and Bronze Paints.—Bronze powders, either gold colour or any of the others obtainable, are used with this. Dissolve 1 part of gum arabic in 4 parts of pure soft water. When dissolved, add 1 part of soluble potash water glass (silicate of potash). The bronze powder is added to this in suitable quantity.

Another Method. — Dissolve gum arabic in pure soft water to a thick consistence. To each quart of this add 1½ oz. of powdered borax. Stir until the whole is a thick jelly, then dilute with warm water as required. The powder can be added at once, or the fluid and powder can be kept in separate bottles.

Painting on Glass.—(*See also* TRANSPARENT PAINTS FOR GLASS).—The different compounds for painting glass are glasses of easy fusion, chiefly coloured with ground metallic oxides, laid on the glass with spirits of turpentine. In the production and modification of glass colours, much depends on the different preparations of the metals, on the small proportion of the metallic oxides employed in proportion to the vitreous mass, on the degree of fire and time of its continuance, and on the purity of each ingredient intended for vitreous mixtures; even then difficulties arise which a skilful operator cannot always remove, and which often frustrate his intention.

Having made choice of the subject to be painted, correctly draw the same on a paper exactly the size intended to be on the glass, then place the different pieces of glass in order on the drawing, and trace the outlines therefrom on to the glass; when the tracing is quite dry, the ground colours

may be washed in, together with the dark and prominent shades, and the stains required. The stains are laid on in various thicknesses, according to the depth of colour required, and when they are dry the glass is ready to be burned in a muffle or kiln constructed for the purpose. The panes of glass are laid on sheets of iron, or earthenware bats, the size of the glass, previously spread over with dried ground flint to prevent the surface of the glass from being defaced. After the first burning, the stain is washed off with warm water, which will bring to view every part of the subject, in fact, every shade according to the thickness of colour applied; to heighten the colour, paint on each side of the glass, and burn it a second time. The glass will require four to six firings, the exact number of firings depending on the subject, the degree of perfection required, and the manner of execution; but after each burning, the pieces of glass will want less labour, some of the colours and stains being perfect at the first and second burning, and few require the utmost quantity. The proper degree of heat to which the glass must be exposed in the muffle is ascertained by taking out at different intervals small pieces of glass, arranged for the purpose, on which are laid similar colours to those being fired. After the glass is burned, it requires great precaution in cooling, for if suddenly cooled it is apt to fly, consequently all sudden changes of temperature should be avoided.

RED, ORANGE, AND YELLOW STAINS.—12 parts calcined green vitriol, 1 oxide of silver. The vitriol must be calcined to a reddish colour, and repeatedly washed with boiling water until it is completely freed from acid, which will be known by the water being insipid to the taste; then triturate the silver and vitriol together in a mortar, after which grind them up with spirits of tar for use. Various temperatures in burning produce various coloured stains, the highest a red, a less an orange, and so on to a yellow; but to procure a deep red, the colour must be laid upon both sides of the glass.

WHITE ENAMEL.—3 parts calcined borax, 2 flint, 1 oxide of tin, 1 Cornish stone. The basis of this enamel, which is in general opaque, may also be employed in assimilating the opaque natural stones. These ingredients must be well mixed up together, and fused in an air furnace in a crucible, the fire at first applied very gradually, and the whole repeatedly stirred with an iron rod. The mixture by this calcination, and by being kept for some time in fusion in an intense heat, acquires its fusibility and opacity.

PURPLE.—(a) 20 parts prepared purple, 2½ enamel flux (2), 1 white enamel.

(b) 20 parts prepared purple, 10 blue, 5½ enamel flux (2), 1 white enamel.

ROSE COLOUR.—20 parts prepared rose colour, 1 white enamel. The purples and rose colours for glass painting are nearly the same mixtures as those used for porcelain painting, with the addition of a small proportion of flux and white enamel. The latter gives firmness to the colour. In the course of working the rose colour, if a very small quantity of purple be added, the colour will be perceptibly benefited.

RED.—1 part terra de sienna, 3 enamel flux (2). The terra de sienna must be calcined over a slow fire until its colour becomes of a dark red, after which it is washed several times in boiling water and ground with the flux for use.

TRANSPARENT ORANGE.—1 part oxide of silver, 10 enamel flux (2), 10 enamel flux (3), 1 white enamel.

YELLOW.—1 part yellow under glaze, 3 enamel flux (2), ½ white enamel.

DARK BROWN.—1 part highly calcined copperas, 3½ enamel flux (3).

RED BROWN.—1 part black, 1 red, 1 enamel flux (4).

LIGHT BROWN.—1 part easy calcined umber, 3½ enamel flux (2).

GREEN.—(a) 5 parts cornelian red, 1 prepared purple.

(b) 2 parts blue, 1 yellow.

BLUE.—(a) 8 parts flint glass, 3 red-

lead, 1 potash, 1 blue calx, ½ common salt.

(*b*) 4 parts borax, 4½ flint glass, 1 flint, ½ potash, ½ prepared purple, 1 blue calx.

In preparing these blues, let the materials be calcined in an air furnace, and the whole mass kept in a state of fusion for some time, a fine blue glass enamel will be produced. The cobalt blue calx should be of the finest quality that possibly can be procured, and free from all impurities.

BLACK.—(*a*) 1 part highly calcined umber, 2 calcined borax, 1 red-lead, 1 blue calx.

(*b*) 1 part manganese, 1 black flux.

The best Turkey umber should be procured for the first process, and calcined at the most intense heat that can be produced in an air furnace, after which pound and mix up with the other materials; then calcine the whole together in an air furnace. The degree of heat will be sufficient when the whole mass is in fusion.

INDIGO BLUE.—1 part precipitate of gold, 4½ enamel flux (4), ½ white enamel. These ingredients are simply ground together for use. They produce a beautiful colour on glass, of a fine purple hue. This very expensive colour is adapted principally for painting the draperies of figures, and is very susceptible of being injured by a high degree of heat.

ETCHING AND DEADENING COLOUR.—(*a*) 7 parts red-lead, 2 calcined borax, 2 flint, 1 oxide of tin.

(*b*) 8 parts red-lead, 6 flint glass, 3 flint, ½ green copperas.

The materials of the last two processes must be finely mixed and calcined in an air furnace, each process separately, after which take 2 parts of (*a*) and 3 parts of (*b*), mix them together, and repeat the calcination again in an air furnace; then pound and grind this frit for use, but be particular that it is ground very fine, for much depends on the particles being minutely mixed previous to using. The composition is afterwards laid on the glass with water, and a small quantity of refined sugar dissolved in spring water is applied occasionally; the solution of sugar must be of the consistence of thick oil; should too large a quantity of the solution be added, and by that means condensate it too much, add a few drops of acetous acid to the menstruum; it will immediately regain a proper consistence, and not at all injure the colour. When the deadening is laid on the glass, the figures must be engraved or etched with a pointed instrument made of wood, bone, or ivory, suitable to the subject, and afterwards burnt in a kiln or muffle appropriated for the purpose. It fires at a less temperature than stained glass, although in some instances it will do in the same kiln.

Transparent Paints.—If in a position to coat the glass before putting in frame, excellent effects may be got by using ordinary shellac varnish (made with bleached shellac) tinted with aniline dye. The glass must be slightly warmed before applying the varnish. The strongest spirit of wine should be used for dissolving the shellac and the powdered (not liquid) aniline colours. Sufficient of the colour must be added to the varnish to give the required tint; 1 part of shellac to 8 of spirit is a good proportion. Methylated spirit will do. The varnish should be poured on and floated evenly over the glass (not painted on), and the superfluous quantity returned to the bottle.

Window Paint.—Mix white-lead with boiled oil or varnish, and a small quantity of driers (no turps, which hardens for the time, being a volatile oil, and therefore objectionable in this case); paint this over the glass thinly, and stipple it. If you have not a proper brush, make a large pledget of cotton wool or tow, cover it with a clean bit of linen rag, and quickly dab it over the paint.

Painting Plaster.—Five coats are generally requisite to paint plaster well; but where it is not of a very absorbent nature, four are found to answer. The first is composed of white-

lead, diluted with linseed-oil, to rather a thin consistence, in order that the plaster may be well saturated; and into this is put a small quantity of litharge to ensure its drying. In painting quick plaster, the oil in this coat is entirely absorbed, thus hardening it to the extent of about ⅛ inch deep from the surface. When this is found to be the case, the second coat should also be thin, that the plaster may be thoroughly saturated; and it will be found necessary after this to give other three coats, making in all five. The second coat will be found to be but partially absorbed, and it is therefore requisite to make the third coat a good deal thicker, and to introduce into it a little spirits of turpentine, and such of the colouring pigments already enumerated, as may bring it somewhat near to the tint in which the apartment is to be finished. The fourth coat should be as thick as it can be well used, and should be diluted with equal parts of oil and spirits of turpentine. The colour of it ought to be several shades darker than that which is intended for the finishing coat, and the drying ingredient sugar of lead instead of litharge. These coats ought all to be laid on with much care, both as to smoothness and equality, and each lightly rubbed with sand-paper before the application of the next. The finishing or flatting coat, as it is termed, from its drying without any gloss, is next applied. It ought, like others, to be composed of pure white-lead, ground as already described, and diluted entirely with spirits of turpentine; and it should appear, when mixed, a few shades lighter than the pattern chosen for the wall, as it darkens in the drying. The drying ingredient should be a small portion of japanners' gold size. This coat must be applied with great care and despatch, as the spirits of turpentine evaporate very rapidly, and if touched with the brush after that takes place, which is in little more than a minute after its application, an indelible glossy mark will be left on the surface. Nothing has been said of the time that each of the coats will take to dry sufficiently to receive the next, as that depends much upon the state of the weather, the quantity of driers employed, and the atmosphere kept up in the apartment. It may be observed, however, that under any circumstances the first coat ought to stand a few days before the application of the second; the second a little longer before the application of the third; and the third, unless in four-coat work, should have still longer time to harden. But the coat immediately before the flatting or finishing coat ought not to stand above two days, as much of the beauty and solidity of the work will depend on the latter dying into and uniting with the former.

Sign-Boards.—Sign or pattern boards ought to be chosen of old well-seasoned wood; oak or mahogany is much the best, but many are made of pine, which ought to be sound, straight, close-grained, well dried, and made with pieces let in across the back, to prevent warping. Thus prepared, brush the board over back and front with equal quantities of raw linseed-oil, japanners' gold size, and turpentine, to which add a little ground white-lead, driving or rubbing out the colour well. For the second coat, take equal quantities of white-lead, common spruce ochre, and whiting, all well dried, and ground fine and stiff, separately with raw oil; mix the whole together; add sufficient of gold size to cause it to dry quickly, firm, and hard; dilute with turpentine to a proper consistence, and apply two or three coats of the above colour. When dry and hard, rub it smooth with either sand-paper or pumice and water; then grind equal portions of spruce ochre, whiting, bath-brick, and white-lead, with two parts oil and one part turpentine, adding a little gold size, diluted with turpentine, and apply one, two, or three coats, if necessary, taking care to rub down and wash off the panel after each coat, repeating

rubbing and colouring until the panel is as smooth and level as plate glass; it is then fit to receive the required last coat, to write, marble, paint, or grain upon. The finishing application, whether it be a plain ground, landscape, figure, or letters, ought to stand until thoroughly dry and hard; it should finally be varnished twice over with best body copal or amber varnish, as the delicacy of the painting will admit.

Theatrical Grease Paints.—Grease-paints require to have the properties of being non-injurious to the skin, and being moderately easy of removal. Lard is the usual base, or cocoanut-fat, with either of which is mixed half as much white wax or petroleum wax. The stick, as used, is about 4 in. by ¾ in. Zinc-white and vermilion, in varying proportions, are used for flesh-tints, the quantity being about half a thimbleful for each stick. The colour is worked into the grease by a palette-knife or by a machine. Burnt umber is used for brown tints, carmine for deep red, madder-lake for rose, zinc-white for pure white, yellow ochre and zinc-white for yellow. Perfume is added when required, a little oil of peppermint, ess. bouquet, or almond oil.

Transparent Paints for Glass, etc.—Shellac varnish, made with bleached shellac, can be tinted with any of the various aniline dyes. The glass should be warmed first, if possible, and the powdered dyes used. If required to coat the whole of the glass, pour the coloured varnish on and then drain it off at a corner. This gives better results than a brush.

Another method is to mix ordinary turpentine 1 part, with Venice turpentine 2 parts, and well rub into this Prussian blue, crimson lake, or Indian yellow (or any admixture of these).

Transparent Painting on Linen.—The colours used in transparent painting are mixed with megilp as a vehicle, except in the case of very light colours, when turpentine and copal varnish must be used. The material upon which transparencies are executed is fine muslin; and this, before being worked upon, should be strained in a straining frame, and sized with either gilders' size, isinglass size, or fine colourless gelatine dissolved and properly diluted. After the first coat of size is dry, the muslin will slacken and hang loosely on the frame. It should be stretched; another coat of size applied; and, when dry, the muslin again extended. A small piece of muslin should at the same time be prepared as a trial piece, strained in the same way as the larger piece, and when dry it can be used to determine whether the muslin is sufficiently sized, or whether the colours are in working condition. The design having been prepared, it may be traced, copied, pounced or stencilled upon the prepared muslin, care being taken that the outline from which the tracing is made, consists of strong and decided lines, that stencil plates are made of oiled paper, and that powdered charcoal is used in preference to any other powder for pouncing. The instructions for oil painting will apply equally to painting transparencies, except that for very fine tints sponge can be used with great advantage to rub in broad flat tints, however delicate. Fine effects may be produced by the use of two transparencies, arranged one behind the other. On the front surface is painted all that is required to be seen in the clearest relief, the painting on the surface behind being modified in its effect by being seen through the front surface.

Transparent Painting on Paper.—The same water colours as those of landscape painting are used for transparencies, and the processes are also the same; only it is requisite to be very attentive in washing in the tints with the utmost possible correctness, both with respect to form and to the power of colour, as the surface of the paper must be preserved clear in every part, and this clearness is always more or less injured by washing out or sponging. The paper should be the thinnest

hand-wove drawing paper that can be procured, carefully selected, and free from unevenness or inequality of texture. When the paper has been selected according to the size of the proposed subject, it should be laid on a drawing board and fastened there, with a piece of thick paper beneath, in order that the tints may be distinctly seen during the painting. After having completed the subject so far as relates to the front, it may be cut off, leaving a margin ½ in. in breadth, for the purpose of gluing it down in the following manner. Take a sheet of Bristol-board, or if the subject is larger, a thicker material, for the purpose of preserving the surface of the whole even and flat. From the centre of this board let a piece be cut out corresponding with the size of the painting, which must be placed on a drawing board, with its face downwards. Let it then be covered for a few minutes with a damp cloth, to cause it to expand a little; and in the meanwhile cover, with thick gum or glue, the edges of the aperture in the board, to correspond with the width of the margin cut off with the painting. The damp cloth may now be removed, and the painting turned with its face upwards, placing the board upon it accurately, in such a manner that the margin may adhere securely to the gum or glue in every part. The whole may then be laid on a flat surface to dry. In this way the Bristol-board will form a frame of such width as may be adapted to the painting, and this frame may be afterwards ornamented according to the taste or fancy of the student. It may be observed that the brilliance of a transparent painting will be increased by the opacity of the border by which it is surrounded, and its width should be regulated by the size of the painting. As soon as the whole is thoroughly dry, the painting must receive such additions at the back as may be requisite to bring it up to the full luminous effect intended. For this purpose, the most convenient position will be one inclined similar to an artists' easel, and immediately in front of a steady light. When the painting has been placed in this position, it will immediately be perceived, that however strongly it may have been previously tinted or touched in the front, a strong light will cause it to appear comparatively feeble. But as the original intention of the workmen will still be impressed on his mind, this weakness in the effect, which only becomes apparent by transmitted light, will suggest the addition of tints to produce the intended power. Where more is required, it must be cautiously applied at the back of the painting, taking all possible care to preserve the colours clear, and not to injure or ruffle the texture of the paper, repeating the tints till the due power is obtained. When considerable power is required, such colours of Indian red, Cologne earth, or vermilion, must be selected as having a semi-opaque body; but care must be taken not to lay them on so thickly as to produce blackness. When richness is required, lake, Prussian blue, and gamboge, which are perfectly transparent, are well adapted to communicate not only richness but delicacy and power to finish. When, by carefully employing the means just pointed out, all possible harmony and effect have been imparted to the painting, it may be rendered partially or wholly luminous, by judiciously applying mastic spirit varnish. With a camel-hair pencil moderately charged with this varnish, let such parts as are in the highest lights be carefully touched, as well as the major part of the sky, and the principal objects of the piece, together with whatever part may require it, in accordance with the character of the scene. If the whole of the subject is covered, it will be requisite to spread the varnish with a flat camel-hair brush, passing it quickly from side to side, and from top to bottom, so that the varnish may be equally spread with all possible expedition. The picture must then be left to dry. After the varnish has become dry, by mixing a little ox-gall in the

water used for the colours, additional beauty of tint, as well as harmony, may be imparted to such parts as appear crude or harsh.

Woodwork Painting.—One of the attendant drawbacks of houses that are newly built, or have been hastily finished for letting, is the inferior painting of the woodwork, and its speedy destruction. The wood is not thoroughly dry, and the consequence is the preparatory coat does not adhere; the pores being full of dampness, it is impossible for the oil to sink into them, especially as oil and water are immiscible. Another equally injurious condition is the gum-resin which exudes from the knots of new pine and other timber. Painted over before it has time to come to the surface, the coat is destroyed by the action of the gum. Now, these evils have to be endured so long as the wood has no time to get seasoned. The painter follows the carpenter without any interval of time, and before the action of the weather can bring out the moisture and resinous substances. A coating of shellac is usually given to the knots, though this is often so thin as to be worthless. Crude petroleum, as a preservative coat, is found to be an admirable preparation for the painting. The petroleum is thin, and penetrates the wood, filling up the pores, and giving a good ground for the coats of paint. According to one American authority, the preparation is of great value. The priming coat should be thin and well rubbed in, and it is better to use a darker colour than white-lead as a base. White-lead forms a dense covering to the surface, though it has its disadvantages. When petroleum has formed the first coat, two other coats will suffice, one being the priming coat, and a third coat may be given after the work has stood for a season. It is a very desirable plan to leave the painting, or rather finishing coats, for a time, so that any imperfections in the wood or work may be discovered; it also allows time for any change of colour that may be made. After the priming coat, it is usual in good work to stop all cracks, nail-holes, and other defects with putty; but in the commoner class of paintings, the coats are laid on quickly; the preceding coat has hardly time to dry before the next is put on, and all the defects of wood, bad seasoning, exudation of gum, etc., quickly begin to show themselves through and disfigure the work. A good paint ought to possess body power of covering up, of flowing evenly from the brush, and become hard. Though zinc-white has less body than white-lead, it is more durable, and will stand sulphur acids without blackening. Some colours stand better than others; the ochres, Indian and Venetian reds, burnt and raw umber are reliable, and may be used without scruple. It is also worthy of notice that salt air acts injuriously on white-lead, and zinc-white is therefore preferable in situations exposed to the sea-air. ('Eng. Mech.')

Painting Zinc.—The difficulty of making oil colours adhere to zinc is well known. Some time since, Prof. Böttger published a process which consists in applying with a hard brush a mordant composed of 1 part copper chloride, 1 copper nitrate, 1 sal-ammoniac, and 64 water, to which is added afterwards 1 hydrochloric acid. The zinc immediately becomes intensely black, which changes in drying (12 to 24 hours) to a dirty whitish grey, on which oil colours may be laid, and to which they will adhere firmly, and withstand both heat and damp.

Artistic Painting in Oil Colours.—The implements and materials necessary for artistic oil painting are oil, varnish, colours, brushes, palette, palette knife, easel, rest stick, canvas, and a little chalk or crayon.

Palettes.—Palettes are made of mahogany, and of satin and other light-coloured woods also; those made of the latter are preferable, because the colours and mixed tints are best seen upon them. They should be light in weight, and thin, and so perforated as to rest well-balanced on the thumb.

Palettes are made of oval and oblong shapes; the latter form is more generally useful and convenient, as affording a greater space for the working of tints, as well as for their advantageous arrangement. Wooden palettes should be prepared for use by rubbing into them as much raw linseed-oil as they can be made to imbibe. If this dressing with oil be thoroughly effected, and the palette be then suffered to dry till it becomes hard, the wood will subsequently not be stained by the absorption of colour. A palette thus prepared is easily cleaned, and presents a hard and polished surface, exceedingly agreeable for the preparation of tints. It is important to keep the palette free from indentations and scratches, and on no account to neglect cleaning it; the colour never being allowed to harden upon the wood.

Easel.—The easel is a frame which supports the painting during its progress. Easels are of various forms; but the most convenient is undoubtedly the rack-easel, which allows the painter to raise or lower his work with speed and convenience, as occasion may require. The commoner and cheaper kinds are supplied with pegs for this adjustment of the height of the work. It is desirable that the easel should stand firmly, and not be liable, as is too often the case, to be overset by any slight cause.

Rest, or *Mahl Stick.*—This is used to rest or guide the right hand or arm when particular steadiness is required, as is the case in the painting of small objects and minute details. It is usually formed of cane or of lance-wood, and it should be light, yet firm. The lower end of the stick is held in the left hand, while the upper extremity, which is covered with a soft round ball or pad of leather, to prevent injury, rests on the canvas or some other convenient support.

Brushes.—To paint with effect, it is of the first consequence to have the brushes well selected, and of the best quality that can be procured. They are of various kinds: of hog-hair, sable, badger, fitch, and goat-hair. Of these, the most useful are the hog-hair, sable, and badger brushes. The black fitch and white goat-hair are but seldom used, as the sable and hog tool will effect all that can be done by the former. Nothing can be superior to a well-made, fine, white bristle tool, in larger work; or to a good red sable for details.

Hog-hair Tools.—These brushes are made both round and flat. Flat hog-hair are generally more useful than round ones; they are preferred, as assisted in giving a squareness and crispness of touch. They should be strongly and neatly made; and in selecting them be sure that the hair has not been cut at the points, for this is sometimes done with inferior brushes; but such brushes have an unpleasant and coarse touch, laying on the colour in a scratchy manner. It will be found to be a good test, if they be made of a very fine silky-looking hair, and be very soft to the touch. They should however be firm, yet elastic; springing back to their form after being pressed laterally upon the hand. Lastly, the shape should be flat and wedgelike, without straggling or diverging hairs. Let the handle be of cedar, and polished; the cedar is pleasant and light to hold, and being polished is easily cleaned. The old white pine handles, sooner becoming ingrained with colour, are both dirty and disagreeable to work with.

Sable Brushes.—The observations regarding hog-hair tools will apply to the sable tools; but these latter should have the additional property of coming to a fine, yet firm point. Be careful in choosing sable brushes, the hair of which is of a pale yellowish cast; and see that the brush is firm, and that it springs well to its point. The round sable tool is as serviceable as the flat one, and is used in working the finishing parts of a painting. Round brushes in quills, known by the name of sable pencils, are also applicable to the same purpose. Pencils that bag or swell where the hair is inserted in the quill,

or the hairs of which diverge and form several points, are worthless.

Badger tools are of various sizes; and the hair, instead of coming to a close end or point, as in other brushes, diverges or spreads out, after the manner of a dusting brush. When good, the hair is long, light, and pliant, of a reddish brown or black, with clean white ends. The chief use of the badger tool is to soften or sweeten broad tints, such as skies, water, distances, and the like; it is a very valuable assistant to the young painter; but must be used with caution, because its injudicious use frequently destroys forms, and produces woolliness. If the badger tools be much employed on a large surface of colour, the points of the hair frequently become so loaded with colour, that it is necessary to clean often. This is best done by pinching up the brush rather tightly at the ends, and wiping it on a clean rag. The brush is thus kept free from colour during the progress of the work, which might otherwise be sullied and deteriorated in the purity of its tones. The badger brush is also useful to the landscape painter, for carrying minute points of colour into those wet parts of the work which require to be lightened, enriched, or varied.

Cleaning Brushes.—All brushes, after being used, should be carefully cleaned. This is best effected by immersing the hair of the brushes in a little raw linseed-oil; the oil should afterwards be washed out with soap and warm water, till the froth which is made by rubbing the brushes on the palm of the hand is perfectly colourless. The brushes should next be rinsed in clean water, and the water pressed out by a clean towel. The hair should then be laid straight and smooth, and each brush restored to its proper shape, by passing it between the finger and thumb, before it is left to dry. Care should be taken not to break the hair by too violent rubbing, as that would render the brushes useless. Many painters use turpentine instead of linseed-oil in the cleaning of brushes; it effects the object more quickly, but the only use of turpentine that should be permitted, is to rinse the brushes in it slightly, when it is required to clean them quickly; on no account should they be permitted to remain soaking in the turpentine, as this practice is certain to injure the brushes, rendering the hair harsh and intractable, and frequently dissolving the cement by which the hair is held in the socket of the handle.

Canvas.—This is the general material used for painting. It is kept prepared in rolls of various widths, and is sold also strained on frames of any required size. The ground or preparation of the canvas should be thin, yet completely covering the threads of the fabric; and it should be free from projecting lines and knots.

Take suitable new canvas, stretch it well upon a stretching frame, wet it well with clean water, and afterwards dry it thoroughly; then stretch it a second time. Grind equal quantities of white-lead and whiting, well dried, with 5 parts of raw oil, and add 1 part boiled oil; prime the cloth over on the face with a brush, palette knife, or trowel; the last is preferable to those who can use it. After the canvas has had sufficient time to dry, scrape off from the back any superabundant colour which may have passed through it; then repeat a second coat on the face, leaving it as smooth as possible. When hard and dry, rub it smooth with a piece of light pumice and water, so as to cut off or lay all the knots in the canvas; then grind 2 parts white-lead, 2 parts whiting, and 1 part burnt ochre, with a small quantity of pumice, all well ground separately rather stiff in raw oil; afterwards mix the whole, adding a little gold size, dilute with half raw oil and half turpentine, and apply a third, fourth, or fifth coat; repeat rubbing down with pumice and water until smooth enough for painting upon.

Oil Sketching Paper is an extremely serviceable material for the young artist. It is made of drawing paper,

covered with two or three coats of oil colour, so as to furnish a ground similar to that of prepared canvas. It is cheap and portable, and serves very well for early attempts and for preparatory sketches; for trying the effects of any work previous to its commencement, as well as during its progress. The paper has this advantage, that, if the sketch is required to be preserved, it can readily be pasted or glued upon the canvas, and then mounted on a deal frame, when it will present the appearance of strained canvas.

Grounds.—Much diversity of opinion has existed respecting the colour of the surface of the prepared canvas. It is a subject of considerable importance, for it is impossible to paint a richly coloured picture, with life and warmth, upon a dull unsuitable ground. A landscape, if carefully handled, can be brought on and finished in a more brilliant manner on a white ground than on any other. It has, however, been objected to a purely white ground, that it is liable to impart a cold chalky effect; but it must be remembered that what is at first white in oil, becomes in a short time of a yellowish hue, and its coldness of tone is thereby lowered. The white, or pale cream-coloured, and pale warm drab-coloured grounds, seem to surpass all others. The reason is that they throw a light and consequently a transparency, through the work; and as all colours in oil painting have a tendency to sink into the ground on which they are laid, and to become darker, this tendency can be counteracted only by having grounds of considerable lightness and brilliancy.

Cold grey grounds have been used in landscape painting; but they impart a heaviness of colouring much to be avoided. Some artists have painted on grounds of a dull red or leather-coloured tint, and much richness may be gained by such; but after a time the colours of any portion that may have been thinly painted sink into this strong ground, and the effect produced is heavy and disagreeable. Upon the whole, a white ground is to be preferred, as soon as the learner has acquired some experience of the subsequent effect of his colours; but as the inexperienced find much difficulty in preventing the coldness and poverty of expression which it is likely to cause under their hands, it will be advisable for the beginner to take the usual light stone drab that is generally given to canvas; for it furnishes him with a middle tint or tone to start from, which, when visible in shadows and middle tints, has not the raw chalkiness shown under similar circumstances on an unskilfully or imperfectly covered white ground.

Vehicles are used to temper and thin the colours, for the purpose of bringing them to a proper working state. All oils or varnishes act more or less to the eventual prejudice of the colour with which they are combined for application. What is desired in oil painting is a vehicle which, while it has an agreeable working quality, shall neither change nor be degraded by time, nor interfere with the purity of the tints as they appear at the moment they are first laid on—a vehicle, that shall neither perish nor crack as it becomes old.

Oils.—Linseed, poppy, and nut oils are the fixed oils used as vehicles; turpentine and occasionally spike-lavender are the essential oils so used. Of the fixed oils, linseed is in most common use. It should be of a pale amber colour, transparent, and limpid; and, when used in moderately warm weather it should dry in a day. The most valuable qualities of linseed-oil, as a vehicle, consist in its great strength and flexibility. It is by far the strongest oil, and the one which dries best and firmest under proper management. The next in importance is poppy oil. It is inferior in strength, tenacity, and drying, to linseed-oil; but it has the reputation of keeping its colour better than linseed-oil; and it is on this account generally employed in grinding white, and most of the light

pigments. Nut oil is more uncertain in its qualities than either linseed or poppy oil; and is frequently extremely long in drying. Poppy oil, however, supplies its place so well, that it is not commonly required. Oils are all more or less influenced in their drying by the colours with which they are combined; some of which greatly accelerate, while others retard it. With certain colours some oils will scarcely dry at all, unless means are employed to cause them to do so.

Japanners' Gold Size is sometimes employed as a powerful means of drying dark and transparent colours, which are in general comparatively bad driers.

Megilps.—The vehicles known by this name are in great favour with artists. They possess a gelatinous texture, which enables them, while flowing freely from the pencil, to keep their place in painting and glazing. The megilp generally in use is formed by mixing together equal parts of strong mastic varnish and drying oil. After remaining undisturbed for a few minutes, it assumes a gelatinous texture, resembling a thin, transparent, amber-coloured jelly. Megilp varies in colour, as it is made with either a pale or deep-coloured drying oil. The palest is made by using instead linseed-oil, in which a small quantity of finely-ground sugar of lead has been diffused. With equal parts of this compound and of mastic varnish, a very light megilp is obtained. Another megilp is made by mixing 1 part of a saturated solution of sugar of lead in water, with 2 parts of linseed or poppy oil. These are well stirred or shaken together till they are combined; and then 2 parts of mastic varnish are added, and well mixed with the preceding. By this means a white creamy emulsion is obtained, which, though opaque in use, becomes quite transparent as it dries. A compound used occasionally in combination with megilp, and consisting of 1 part of copal varnish, 1 part of linseed or poppy oil, and 1 part of turpentine, will furnish a pleasant and serviceable vehicle for general use. Care must be taken, however, to force its drying by the addition of ground sugar of lead, when employed with slow-drying pigments.

Glazing.—A glaze is a thin transparent film of colour, laid upon another colour to modify the tone, or to aid the effect of the latter; the work thereby appearing distinctly through the superimposed layer of glaze, from which it receives a characteristic hue. Glazing is effected by diluting proper transparent colours with megilp or other suitable vehicle. Thus diluted, these colours are laid upon portions of the work, either in broad flat tints, or in touches partially and judiciously distributed. The object of this process is to strengthen shadows, and to give warmth or coldness to their hue: to subdue lights that are unduly obtrusive, or to give additional colour and tone to those that are deficient in force and richness. Should it be necessary to lighten the tone of any part of the picture, this cannot be done by merely glazing; the first tints must first be concealed with brighter colours, of sufficient body for that purpose, and the glaze may then be applied. The glaze should usually be darker than the ground colour upon which it is to be laid; and as a rule, it may be observed that the first painting of the picture should be brighter than the subject may require, in order that the subsequent glazings may lower and obscure it to a proper and effective degree of tone. Glazing is generally effected by the application of diluted transparent colours; but occasionally semi-transparent colours are used for this purpose, provided they are rendered sufficiently transparent by the admixture of a large proportion of vehicle. These latter glazings are capable of being applied with excellent effect, where it may be necessary to modify the tones of those parts of the picture which do not appear satisfactory, or to produce particular effects, such as representations of smoke, dust, mists, and the like. Caution is however, necessary in glazing with opaque colours; because, if

used in excess, they will deteriorate the picture, by destroying its transparency. Should a glazing produce a result different from what was intended, the glaze may easily be removed by a rag, or, if the spot be small, by the finger, provided the removal be effected *immediately*, that is, before the glaze has had time to fasten itself upon, or to soften, the colour on which it is laid, and in no case must glazing be attempted before the colours over which it is laid have become perfectly dry and firm.

Impasting.—In oil painting, the shadows or dark portions of the picture are painted thinly, while the lights are laid on or impasted with a full pencil and a stiff colour. In the lights of the foreground, and of parts not intended to be remote, or to retire, the impasting should be bold and free; while in the more brilliant lights, it cannot well be too solid. There is, however, a reasonable limit to the practice; since actual protuberance or prominence of the paint itself will, in certain lights, produce a false shadow, and therefore a bad and false effect. This will be understood, from observing that the loading of thick masses of colour upon the picture, so as to make them project considerably from the surface, is done with the view of their being strongly illuminated by light actually incident upon the picture, and of thus mechanically aiding in the production of roundness and relief, or in giving a sparkling effect to polished objects or glittering points. But this artifice must be had recourse to sparingly and cautiously, else it defeats its own object, and produces a coarse and vulgar air and effect. The palette knife has always been a favourite instrument of this impasting, or laying on of colour, capable as it is of producing an agreeable brightness on, and of giving an appropriate flatness to, the pigment. A clear and appropriate tint, for instance, skilfully swept across a sky by these means, often produces a surprisingly brilliant and charming effect.

Scumbling.—Scumbling, the opposite process to that of glazing, is done by going lightly over the work with an opaque tint, generally produced by an admixture of white. For this purpose a hog-hair brush is employed, charged with colour but sparingly; and with it the tints are drawn very thinly, and somewhat loosely, over the previous painting, which should, as in the case of glazing, be dry and firm. Scumbling is used to modify certain effects, by rendering the portion to which it is applied cooler, greyer, and in fact less defined than it was before, and to give air and distance to objects that seemed too near. It is thus of service both in correcting a tendency to muddiness or dirtiness of colour, and to what may be called hardness or over-distinctness of detail, and in weakening the force of colours that are too powerful by softening and uniting such tints as may be too violently contrasted. It is desirable to avoid, as far as possible, scumbling over shadows, as an inexperienced hand might thus destroy their transparency.

Lining Old Paintings.—(*a*) Take a piece of unbleached calico, strain upon a frame, and size it with weak size. When dry take ¼ oz. spirits of turpentine, 1 dr. camphor, dissolve in it 4 oz. cold-drawn linseed-oil, 2 oz. white-lead, 2 oz. stiff ground umber, 4 oz. finely washed and dried whiting. Mix all together; apply it to the calico, well rubbing it in; after the second coat, pumice to erase the lumps. Give the picture a coat, and pumice that; then coat both, and put them together upon a level board face down upon a piece of brown paper well sized. Well press and rub the air out, so as to bring them in perfect contact, and in a few days it may be tacked upon a frame.

(*b*) Make a temporary stretcher, and let it measure inside a little larger than the outside of the picture about to be lined, and on it stretch some unbleached calico; trim the picture square cutting off all the old and ragged edges. Oil a piece of paper the size of picture with linseed-oil, and lay it on a flat surface; now lay the picture face

downwards on the oiled paper, and coat it with glue or paste until there is sufficient to make it stick well; then lay the unbleached calico on, rub well with the flat of the hand, iron it with flat iron till quite dry, taking care to put a piece of paper between the calico and the iron, or it may stick. Be sure the iron is not too hot; and if it is a large picture, it will be as well to have two irons, one getting hot while the other is in use. When the picture is quite dry it is ready for putting on the new stretcher, which should be one with two cross-bars, and can be obtained at any artists' colourman's. If you cannot make some good stout paste yourself, you had better buy it at the leather seller's, add glue enough to make it a good strength, and let the two be well mixed together.

Preserving a Scaling or Cracked Painting.—The preparation is a mixture of equal parts of linseed-oil and methylated chloroform, which is poured over the painting if the colours are too brittle to bear the friction of a soft brush. After remaining on the surface of the painting for a day or two, the excess of oil may be removed by means of a piece of cotton wool, or a soft brush, a fresh portion of the preservative applied, and the excess removed as before. The process must be repeated from time to time until the colours are firmly fixed when the painting will bear friction, and may be submitted to the cleaning process, or varnished. It is advisable, however, to remove as much of the dirt as possible from the picture, by careful washing with soft water, previously to the application of the fixing agent. The mixture will not restore the cracks in a painting, but simply fixes the colours, and renders the painting very elastic. A mixture of 1 part of methylated chloroform and 2 of linseed-oil is used for reviving the colours of paintings. A small portion is rubbed over the pictures, after washing, with cotton-wool, and on the following day the painting is wiped over with a soft silk handkerchief. Oil and chloroform, when used in the proportion given, possess the property of restoring the faded colours of paintings, and develop colours which have perished, to the eye, by age.

Varnishing Valuable Paintings.—Some artists employ for new paintings white of egg as a varnish, others do not varnish their paintings for one or two years after being finished, when the colours are completely hardened and mellow. Mastic varnish is the only one which can be removed at pleasure, and for that reason is generally preferred to all others, although it is very liable to chill; that is, it becomes all over of a bluish steamy hue, which obscures the beauty of the painting, and appears disagreeable to the eye. Many circumstances contribute towards causing it to chill; for instance, varnish made from weak, unripe gum mastic and common spirits of turpentine will chill, particularly if applied on new paintings, where the grounds, oils, and colours are fresh, soft, and absorbent. In order to prevent this, if possible, employ no varnish but that made from fine, ripe gum mastic and rectified turpentine. Varnish for oil paintings, after being properly made, ought to stand for at least twelve months in large wide-mouthed glass bottles, without a cork, covering the mouth with a piece of glass, so as to admit the air, but prevent dust falling in; place the bottle so as to receive a full light, but no sun. The light and air so change and modify the essential quality of the turpentine, that the varnish becomes elastic, clear and brilliant, having so much improved during that time as seldom or never to chill or become steamy, and by age it loses that attraction which all new-made varnishes possess for moisture and impure exhalations. Therefore, as a preventive against varnish chilling, employ none but good old varnish; never apply it on new or old paintings until properly cleaned, and well dried from moisture; apply the varnish in a warm room, where the painting and varnish also receive a proper warmth,

After the varnish is applied, let it remain until properly dry; recollecting that with all newly-painted pictures, where the grounds and colours are soft and absorbent, and where the pictures are afterwards exposed to strong, moist exhalations, the varnishing in time will chill; but when paintings are properly cleaned and varnished, and afterwards hung up in dry rooms or galleries, there is no reason to fear their chilling.

Harmony of Colours.—Harmony of colour is produced by an equable use and distribution of the primary colours, whether used simply as such, or united in various proportions in their compounds. Harmony is recognised in a picture when nothing exists in it that disturbs the eye by violent opposition or contrast of colours; judicious contrast, however, tends much to produce harmony, when the force of the contrast is diminished by the juxtaposition of tones partaking more or less of the colours employed in producing the contrast. This we shall find is the process employed by nature, the reds in which are harmonised with the contrasting green by hues of orange, or yellow green; and so with other colours. Harmony of colour in painting is best obtained by setting the palette with those pigments which, through the prevalence of any of the primaries, blend with, or, as it were, run into each other. Thus, commencing with white, we proceed to yellow, orange or yellow-reds, red, blue-reds, blues, green-blues, greens, browns, grey, and black. A palette can be set warm or cold, as the subject may require, by selecting pigments in which blue predominates or is deficient.

Primaries.	BLUE is contrasted by ..	Red and Yellow,	or Orange.	Secondaries.
	RED is contrasted by ..	Blue and Yellow,	or Green.	
	YELLOW is contrasted by ..	Blue and Red,	or Purple.	
Secondaries.	Orange or	Red and Yellow	is contrasted by BLUE.	Primaries.
	Green, or	Blue and Yellow,	is contrasted by RED.	
	Purple, or	Blue and Red,	is contrasted by YELLOW.	

Artistic Painting in Water Colours.—The practice of the art consists of sketching the outline, of tinting or shading with sepia, bistre, or india-ink; and of the application of the pigments, in three or more successive stages, to the attainment of a finished drawing. Instructions must, of necessity, be of a general character, because almost every artist of genius finds out for himself and practises some peculiar methods of applying the pigments, which can only be learned by those who become his pupils. These peculiar methods constitute the various styles of the masters of the art, by which their works are so readily recognised and distinguished.

Materials.—The principal materials required by the painter in water colours are drawing paper, ivory for miniatures, drawing board, pigments or colours, lead pencils, hair pencils or brushes, palettes, slabs, saucers, cups or glasses for holding water, sponge, gum water, ox-gall, rubber, drawing pins, sharp convex-pointed knife, and flat ruler.

Room.—The choice of a situation for the practice of painting is not a matter of indifference. The room should be well lighted, of a northern aspect, if possible, and free from reflected colours from opposite objects. As dust and grease are inimical to the delicacy and integrity of water-colour painting, it will be the first care of the student to guard against them. The light should fall on the left hand of the painter, and not be admitted below the head. A room lighted from above, or by a skylight, is much to be preferred.

Pencils or Brushes.—The hair pencils or brushes used in water-colour painting are made of camel-hair and of fitch or sable. The best are those known as soft brown or black sables; those made of red sable are not so useful, as they possess the bad quality of stiffness, and disturb the colours by their harshness. These brushes will hold a considerable quantity of fluid, and should be used full, but not overflowing so as to become unmanageable. After using, they should be carefully washed in clean

water, and then slightly pressed in a piece of clean linen rag. A brush put away unwashed, especially if it has been used for india-ink, or any dark pigment, can scarcely ever be cleaned again so as to be fit to use with light or delicate pigments. For large drawings, brushes are prepared, both round and flat, mounted in tin; these are also useful in washing. The most essential quality of a good pencil is that it should yield a good point, for it is that part only which is used; the hairs when moistened should form a cone terminating in a fine and delicate point. It should also be firm yet elastic, returning to a straight direction immediately upon being lifted from the paper.

Management of Drawing.—The manipulation in water-colour painting is of the greatest simplicity, consisting merely in selecting the pigments required, mixing from them the various tints the subject demands, and leaving them in their proper places upon the paper. These pigments are rubbed with boiled or distilled water, on earthenware slabs, with the addition of a small quantity of gum water, for the strong marking of the shadows, and so on. It is the usual practice to lay on the first tints or washes with the hard-cake pigments ground on the slabs, while the middle or foreground is painted with the soft or body-colours, which, by remaining constantly moist, are always ready for use. The pigments should be ground in sufficient quantity, and with so much water as to be quite fluid, and capable of entirely filling the brush; the superfluous quantity can be easily removed by slightly pressing the brush on the edge of the palette; for unless the pigments are reduced to this state of fluidity, the drawing acquires a dry and harsh appearance; while, at the same time, an excess of fluidity produces a thinness and meagreness, leaving a dark edge surrounding the coloured surface, which inevitably betrays the inexperienced hand. The progress of a water-colour drawing is that of simply washing with the requisite colours, as a preparatory stage, and proceeding by gradual and delicate additions where they are required, and so on to the finishing, which consists in applying the colours in their full body and strength, giving solidity to the forms, and a definiteness to the outlines that constitutes a finished picture, equal in vigour, freshness, and richness of tone to oil painting. Many parts of the drawing must unavoidably be gone over with colour that should be left white for the high or brilliant lights: the colour must be removed from these places by rubbing with a sharp scraper; or by moistening the spot to be reclaimed with a pencil dipped in clean water after it has remained a few moments, the moisture is removed with a piece of clean blotting paper, and then rubbing the surface of the paper by means of a white handkerchief, rubber, or bread-crumbs.

PAPER.

Astronomical Drawing-paper. Felix Plateau describes in 'Les Mondes' an ingenious process for drawing on paper white lines on a black ground—a method frequently used for astronomical illustrations—by means of which both author and artist are able to judge of the effect of such an illustration before putting it into the hands of the engraver. A piece of thickish paper, as smooth as possible, a little larger than the intended illustration, is heated by laying it, with proper precautions against being injured, on the top of a stove, and a piece of beeswax is rubbed over it until the paper is completely covered with a thin coating. A piece of glass, the size of the paper, is blackened by being held over a candle, and, when thoroughly cooled, it is laid on the waxed paper and rubbed thoroughly with the fingers, the result being that the blackened surface is produced on the paper, on which any design can be traced with a needle for the finer lines, or the back of a steel pen for the thicker ones.

Blotting-paper.—This is a paper whose value consists in its absorbing qualities, and these depend as much upon the mode of preparation as upon the material. For blotting of a high class, cotton rags of the weakest and tenderest description procurable should be chosen. Boil them with 4 lb. caustic soda per cwt.—that is, if you have no facilities for boiling them with lime alone. When furnished in the breaking-engine, wash thoroughly before letting down the roll; then reduce them to half-stuff, and as soon as possible empty into the poacher, or convey to the poacher as the case may be, and bleach with great care. When up to the desired colour, empty into the drainer, and drain immediately. It may be mentioned that the breaker-plate ought to be sharp when starting to blottings. The beater roll and plate should be in good order, and the stuff beaten off smartly, not to exceed 1½ hour in the engine. For pink blottings, furnish ¾ white cottons and ¼ turkey reds, if they can be got; if not, dye with cochineal to the desired shade, empty down to the machine before starting, and see that the vacuum-pumps are in good condition. Remove the weights from the couch roll, and, if there are lifting screws, raise the top couch roll a little. Now take the shake-belt off, as the shake will not be required. Press lightly with the first press, and have the top roll of the second press covered with an ordinary jacket similar to a couch roll jacket. Dry hard, and pass through one calendar with the weights off, and then roll as light as possible—just enough to smooth slightly. (Dunbar.)

Crystalline Paper.—According to Böttger, the simplest method of giving paper surfaces a crystalline coating is as follows: Mix a very concentrated cold solution of salt with dextrine, and lay the thinnest possible coating of the fluid on the surface to be covered, by means of a broad soft brush. After drying, the surface has a beautiful bright mother-of-pearl coating, which, in consequence of the dextrine, adheres firmly. Prof. Böttger mentions the following salts as adapted to produce the most beautiful crystalline coating: sulphate of magnesia, acetate of soda, and sulphate of tin. Paper must first be sized, otherwise it will absorb the fluid and prevent the formation of crystals on its surface. Visiting cards with a mother-of-pearl coating have for some time been in use. Coloured glass is well adapted for such a coating, which has a good effect when the light shines through.

Deciphering Burnt Documents.—Rathelot, an officer of the Paris law courts, succeeded in an ingenious manner in transcribing a number of the registers which were burnt during the Commune. These registers remained so long in the fire that each seemed to have become a homogeneous block, more like a slab of charcoal than anything else, and when an attempt was made to detach a leaf

it fell away into powder. Many scientific men examined these unpromising black blocks, when Rathelot hit upon the following method of operation: In the first place, he cut off the back of the book so as to leave nothing but the mass of leaves which the fire had caused to adhere to each other; he then steeped the book in water, and afterwards exposed it, all wet as it was, to the heat at the mouth of a furnace; the water, as it evaporated, raised the leaves one by one, and they could be separated, but with extraordinary precautions. Each sheet was then deciphered and transcribed. The appearance of the pages was very curious; the writing appeared of a dull black, while the paper was of a lustrous black, something like velvet decorations on a black satin ground, so that the entries were not difficult to read.

Enamelled Paper.—1 lb. of parchment cuttings, ½ lb. of isinglass, and ½ lb. of gum arabic, in 4 gal. of water, are boiled in an iron kettle until the solution is reduced to 12 quarts; it is then removed from the fire and strained. The solution is divided into three parts of 4 quarts each; to the first portion is added 6 lb. of white-lead, ground fine in water; to the second portion is added 8 lb. of white-lead, and to the third is added 6 lb. of white-lead. The sheets of paper are stretched out upon flat boards and brushed over with a thin coat of the first mixture, with an ordinary painters' brush; the paper is then hung up to dry for 24 hours. After this, the paper is ready to receive a coat of the second mixture, and again hung up to dry for 24 hours; the paper is then treated in the same way with the third mixture, and dried for 24 hours. After this it receives a high gloss, which is obtained by laying the work with its face downwards on a highly-polished steel plate, and then passing both with great pressure between a pair of powerful rollers. It is to be regretted that this enamelled surface is not very durable, as it comes off after wetting. To prevent this, a solution of some resinous substance may be added in the last operation.

Filtering-paper.—That usually employed is blotting-paper. S. H. Johnson makes a kind by mixing 5 to 20 per cent. of purified animal charcoal powder with the pulp, which is preferably long-fibred.

Hardening Paper.—The French papers speak of a method of rendering paper extremely hard and tenacious, by subjecting the pulp to the action of chloride of zinc. After it has been treated with the chloride, it is submitted to a strong pressure, thereafter becoming as hard as wood and as tough as leather. The hardness varies according to the strength of the metallic solution. The material thus produced can be easily coloured. It may be employed in covering floors with advantage, may replace leather in the manufacture of coarse shoes, and is a good material for whip-handles, the mountings of saws, for buttons, combs, and other articles of various descriptions. An excellent use for it is large sheets of roofing. Paper already manufactured acquires the same consistence when plunged, unsized, into a solution of the chloride.

Incombustible Paper may be made by mixing with the pulp a fluid obtained by adding to an aqueous solution containing 1¾ oz. of pure tallow soap, just enough alum to completely decompose the soap. The paper made with this requires no size. (See also ii. 291.)

Iridescent Paper.—Boil 8 oz. nutgalls, 5 oz. iron sulphate, 4 oz. sal-ammoniac, 4 oz. indigo sulphate, 2 dr. gum arabic, in water, wash the paper with it, and expose to ammonia vapour.

Ivory Paper.—The properties which render ivory so desirable for artists are, the evenness and fineness of its grain, its allowing all water colours laid on its surface to be washed out with a soft wet brush, and the facility with which the artist may scrape off the colour from any particular part, by means of the point of a knife,

or other convenient instrument, and thus heighten the lights in his painting more expeditiously and efficaciously than can be done in any other way. These advantages are obtained in the paper made according to the following receipt, without any of the disadvantages of ivory, such as its limited size and changeable colour. Traces made on the surface of ivory paper by a hard black-lead pencil are much more easily effaced by rubber than from common drawing-paper, which, together with the extremely fine lines which its hard and even surface is capable of receiving, peculiarly adapts it for the reception of the most delicate kind of pencil-drawing and outlines. The colours laid upon it have a greater brilliance than upon ivory, owing to the superior whiteness of the ground.

Take 1 lb. of clean parchment cuttings and put them into a 2-quart pan, with nearly as much water as it will hold; boil the mixture gently for 4 or 5 hours, adding water from time to time to supply the place of that driven off by evaporation; then carefully strain the liquor from the dregs through a cloth, and when cold it will form a strong jelly, which may be called size No. 1. Return the dregs of the preceding process into the pan, fill it with water, and again boil it as before for 4 or 5 hours; then strain off the liquor, and call it size No. 2. Take three sheets of drawing-paper—outsides will answer the purpose perfectly well—wet them on both sides with a soft sponge dipped in water, and paste them together with the size No. 2. While they are still wet, lay them on a table, and place them upon a smooth slab of writing slate somewhat smaller than the paper, turn up the edges of the paper, and paste them on the back of the slate, and then allow the paper to dry gradually. Wet as before three more sheets of the same kind of paper, and paste them on the others, one at a time; cut off with a knife what projects beyond the edges of the slate, and when the whole is perfectly dry, wrap a small piece of slate in coarse sand-paper, and with this rubber make the surface of the paper quite even and smooth. Then paste on an inside sheet, which must be quite free from spots or dirt of any kind; cut off the projecting edges as before, and when dry rub it with fine glass-paper, which will produce a perfectly smooth surface. Now take ½ pint of the size No. 1, melt it with a gentle heat, and then stir into it 3 table-spoonfuls of fine plaster-of-Paris; when the mixture is complete, pour it out on the paper, and with a soft wet sponge distribute it as evenly as possible over the surface. Then allow the surface to dry slowly, and rub it again with fine glass-paper. Lastly, take a few spoonfuls of the size No. 1, and mix it with three-fourths its quantity of water; unite the two by a gentle heat, and when the mass has cooled so as to be in a semi-gelatinous state, pour one-third of it on the surface of the paper, and spread it evenly with the sponge; when this has dried, put on another portion, and afterwards the remainder; when the whole has again become dry, rub it over lightly with fine glass-paper, and the process is completed; it may accordingly be cut away from the slab of slate, and is ready for use. The quantity of ingredients above mentioned is sufficient for a piece of paper 17½ by 15½ in. Plaster-of-Paris gives a perfectly white surface; oxide of zinc, mixed with plaster-of-Paris, in the proportion of 4 parts of the former to 3 of the latter, gives a tint very nearly resembling ivory; precipitated carbonate of baryta gives a tint intermediate between the two.

Lithographic Paper.—(1) To prevent ink from adhering to and sinking into lithographic paper, which would render a perfect transfer to the stone impossible, the following plans are used: (1) Coat the paper with three successive layers of sheep-foot jelly, one of cold white starch, and one of gamboge. The first coat is applied by a sponge dipped in the hot solution of jelly, thinly but very evenly over

the whole surface; the others are applied in succession, each previous one being allowed to dry first. When the paper is dry, it is smoothed by passing through the lithographic press. (2) Cover rather strong unsized paper with a varnish composed of 120 parts starch, 40 of gum-arabic, and 20 of alum. Make a moderate paste of the starch by boiling, dissolve the gum and alum separately, and then mix all together. When well mixed, apply hot with a flat smooth brush to the leaves of paper. Dry and smooth by passing under the press.

(2) Make strong separate solutions in hot water of gum arabic 2 parts by weight, starch 6, alum 1. Mix, and whilst moderately hot, give the paper two or three coats with a brush, allowing each coat to dry before the next is applied; finish by pressing. Another plan is to smear the paper with several cold coats of thin size, and then use solutions of white starch and gamboge water, allowing each coat to dry as before. Paper thus prepared is written on with litho. transfer ink, the back wetted, placed on a clean stone, and run through the press, when a reverse copy is obtained, which can be printed from in the usual way.

Luminous Paper.—A luminous and damp-proof paper is prepared by adding phosphorescent powder and gelatine to the pulp. The proportions are: 10 parts water, 40 paper pulp, 20 phosphorescent powder (preferably slacked for 24 hours), 1 gelatine, 1 saturated solution potash bichromate. (*See also* LUMINOUS SUBSTANCES.)

Manifold Writing or Carbon Paper.—The white paper is only very fine thin writing-paper. The black is soft paper, prepared by being smeared with a composition of grease and plumbago or lampblack; this mixture is allowed to remain on for 12 hours, and the paper is then wiped smooth with a piece of wool or cotton-waste. Place white paper over black, and write with a blunt point.

Oiled Paper.—(1) Brush sheets of paper over with boiled oil in which a little shellac has been carefully dissolved over a slow fire; suspend on a line till dry. (2) The paper is laid on a square board, and well covered with a mixture composed as follows: boiled linseed-oil is reboiled with litharge, lead acetate, zinc sulphate, and burnt umber, 1 oz. of each per gal. The first sheet is covered on both sides, the second, placed on this, receives one coating, and so on; separate, and hang up to dry.

Packing-Paper.—(1) Packing-paper may be made water-tight by dissolving 1·82 lb. of white soap in 1 qt. water, and dissolving in another qt. 1·82 oz. (apothecaries' weight) gum arabic, and 5·5 oz. glue. The two solutions are mixed and warmed, the paper is soaked in the mixture, and passed between rollers or hung up to dry. (2) The paper is treated with boiled linseed-oil, the excess of oily particles being removed by benzene; it is then washed in a chlorine bath, and, after drying, treated with hydrogen peroxide. If the paper has been made from ropes, it is coated with a layer of starch before the treatment with linseed-oil and benzene. The final operation is "satining," by a passage through smooth rollers. (3) Russian oil-cask bottoms are often pasted over on the outside with a kind of paper having a gelatinous-looking skin, and which is quite oil-tight. Such has been brushed over with a mixture of blood and lime, a preparation much used in Russia and China, and quite oil- and water-tight. Chinese packing-cases are often pasted over with paper painted with this mixture. The Chinese *schio-lios* is made by mixing 3 parts fresh blood (beaten up till free from fibrine) with 4 of dry powdery slaked lime and a little alum. The thin pasty mass thus obtained may be used at once.

Paper Powder.—Boil white paper, or paper cuttings, in water for 5 hours. Pour off the water, pound the pulp in a Wedgwood mortar, and pass through a fine sieve. This powder is employed by the bird-stuffers to dust over the

legs of some birds and the bills of others, to give them a powdery appearance; also to communicate the downy bloom to rough-coated artificial fruit, and other purposes of a similar nature; it makes excellent pounce.

Safety-paper.—Paper which has been passed through a solution of glue with 5 per cent. potassium cyanate and antimony sulphide, is immersed in a dilute solution of magnesium or copper sulphate, and afterwards dried. Nothing written on this paper with ink prepared from galls and iron salts can be destroyed by acids, etc., nor by mechanical erasing. Acids would colour the black writing blue or red, while alkalies would colour the paper brown; erasing would remove the surface of the paper, and show the white ground.

Smoothing Paper.—Lay the paper, face downwards, on a sheet of smooth unsized white paper; cover it with another sheet of the same, very slightly damped, and iron with a moderately warm flat-iron.

Splitting a Sheet of Paper.—People who have not seen this done might think it impossible; yet it is not only possible, but extremely easy. Get a piece of plate-glass, and place on it a sheet of paper; then let the latter be thoroughly soaked. With care and a little dexterity, the sheet can be split by the top surface being removed. But the best plan is to paste a piece of cloth or very strong paper to each side of the sheet to be split. When dry, violently and without hesitation pull the two pieces asunder, when part of the sheet will be found to have adhered to one and part to the other. Soften the paste in water, and the pieces can be easily removed from the cloth. The process can be utilised in various ways. If it be wanted to paste in a scrap-book a newspaper article printed on both sides of the paper, and there is only one copy, it is very convenient to know how to detach the one side from the other. The paper when split, as may be imagined, is more transparent than before, and the printing-ink is somewhat duller.

Test-papers. *Litmus.*—To prepare litmus-paper, rub good litmus with a little hot water in a mortar, and pour the mixture into an evaporating basin; add water until the proportion is ½ pint water to 1 oz. litmus; cover up so as to keep warm for an hour, after which the liquid must be filtered, and fresh hot water poured on the residue. This is boiled, covered up as before, and allowed to stand. The operation is repeated a second time, and, if much colour comes, a third time. The first solution is kept separate from the second and third, which may be mixed together. The first will not require evaporation, but the others may be so far reduced in quantity that when a piece of blotting- or filtering-paper is dipped into them and dried, they will impart to it a blue colour of sufficient intensity for use. The paper is then dipped in the solution. The paper—blotting will suit very well—should always be unsized, of good colour, and moderate thickness, say 15 to 20 lb. demy, and cut into pieces of a convenient size for dipping. Particular care should be taken to use paper as free as possible from earthy matter, and especially from carbonate of lime. Sized papers produce a finer tint on the surface, but are not so delicate as a test. Pour the litmus solution into a plate, and draw the slips of paper through it in such a manner that the fluid will come into contact with both sides; allow it to drip, then hang them across two thread lines to dry. The tint ought to be a distinct blue, and may be tested as to its delicacy by touching the paper with a very dilute acid, observing whether the red colour produced is vivid or not. It should, when dry, be tied up into bundles, and preserved from the air and light. A wide-necked glass-stoppered bottle is best suited for the purpose. Put in the test-papers, and paste round the sides of the bottle a piece of dark paper to exclude the light, as both air and light tend to destroy the colour and efficacy of the test-paper.

Turmeric.—This is prepared in a manner similar to litmus-paper. A hot infusion of finely-crushed turmeric is made by boiling 1 oz. turmeric in 12 oz. water for ½ hour; strain through a fine cloth or silk bag, and leave the fluid to settle for a few minutes. The liquid should be of such strength that paper dipped into it and then dried will have a fine yellow colour. The paper should be of the same quality in every respect as for litmus-paper. No particular care is necessary in drying, as with litmus-paper; but both papers should be prepared where acid and alkaline fumes cannot come into contact with them, as they injure the colour of both.

Tracing-paper.—(1) A German invention has for its object the rendering more or less transparent of paper used for writing or drawing, either with ink, pencil, or crayon, and also to give the paper such a surface that such writing or drawing may be completely removed by washing, without in any way injuring the paper. The object of making the paper translucent is that when used in schools the scholars can trace the copy, and thus become proficient in the formation of letters without the explanations usually necessary; and it may also be used in any place where tracings may be required, as by laying the paper over the object to be copied it can be plainly seen. Writing-paper is used by preference, its preparation consisting in first saturating it with benzine, and then immediately coating the paper with a suitable rapidly-drying varnish before the benzine can evaporate. The application of varnish is by preference made by plunging the paper into a bath of it, but it may be applied with a brush or sponge. The varnish is prepared of the following ingredients: Boiled bleached linseed-oil, 20 lb.; lead shavings, 1 lb.; oxide of zinc, 5 lb.; Venetian turpentine, ½ lb. Mix and boil 3 hours. After cooling, strain, and add 5 lb. white copal and ½ lb. sandarach. (2) The following is a capital method of preparing tracing-paper for architectural or engineering tracings: Take common tissue or cap-paper, any size of sheet; lay each sheet on a flat surface, and sponge over (one side) with the following, taking care not to miss any part of the surface: Canada balsam, 2 pints; spirits of turpentine, 3 pints; to which add a few drops of old nut-oil; a sponge is the best instrument for applying the mixture, which should be used warm. As each sheet is prepared, it should be hung up to dry over two cords stretched tightly and parallel, about 8 in. apart, to prevent the lower edges of the paper from coming in contact. As soon as dry, the sheets should be carefully rolled on straight and smooth wooden rollers covered with paper, about 2 in. in diameter. The sheets will be dry when no stickiness can be felt. A little practice will enable anyone to make good tracing-paper in this way at a moderate rate. The composition gives substance to the tissue-paper. (3) You may make paper sufficiently transparent for tracing by saturating it with spirits of turpentine or benzoline. As long as the paper continues to be moistened with either of these, you can carry on your tracing; when the spirit has evaporated, the paper will be opaque. Ink or water-colours may be used on the surface without running. (4) A convenient method for rendering ordinary drawing-paper transparent for the purpose of making tracings, and of removing its transparency, so as to restore its former appearance when the drawing is completed, has been invented by Puscher. It consists in dissolving a given quantity of castor-oil, in one, two or three volumes of absolute alcohol, according to the thickness of the paper, and applying it by means of a sponge. The alcohol evaporates in a few minutes, and the tracing-paper is dry and ready for immediate use. The drawing or tracing can be made either with lead-pencil or Indian ink, and the oil removed from the paper by immersing it in absolute alcohol, thus restoring its original opacity. The alcohol employed

in removing the oil is, of course, preserved for diluting the oil used in preparing the next sheet. (5) Put ½ oz. gum-mastic into a bottle holding 6 oz. best spirits of turpentine, shaking it day by day; when thoroughly dissolved it is ready for use. It can be made thinner at any time by adding more turps. Then take some sheets of the best quality tissue-paper, open them, and apply the mixture with a broad brush. Hang up to dry. (6) Carbon tracing-paper is prepared by rubbing into a suitable tissue a mixture of 6 parts lard, 1 of beeswax, and sufficient fine lampblack to give it a good colour. The mixture should be warm, and not be applied in excess. (7) Saturate ordinary writing-paper with petroleum, and wipe the surface dry. (8) Lay a sheet of fine white wove tissue-paper on a clean board, brush it softly on both sides with a solution of beeswax in spirits of turpentine (say about ¼ oz. in ½ pint), and hang to dry for a few days out of the dust.

Transfer-paper.—Rub the surface of thin post or tissue paper with graphite (black-lead), vermilion, red chalk, or other pigment, and carefully remove the excess of colouring matter by rubbing with a clean rag.

Waxed Paper.—Place cartridge or other paper on a hot iron and rub it with beeswax, or brush on a solution of wax in turpentine. On a large scale, it is prepared by opening a quire of paper flat upon a table, and rapidly ironing it with a very hot iron, against which is held a piece of wax, which, melting, runs down upon the paper and is absorbed by it. Any excess on the topmost layer readily penetrates to the lower ones. Such paper is useful for making waterproof and airproof tubes, and for general wrapping purposes.

Paper Stains. (*See also* STAINS AND STAINING *for other paper stains*). *Crimson.*—A very fine crimson stain may be given to paper by a tincture of Indian lake, which may be made by infusing the lake some days in spirits of wine, and then pouring off the tincture from the dregs. It may be stained red by red ink. It may also be stained of a scarlet hue by the tincture of dragon's-blood in spirits of wine, but this will not be bright.

Green.—Paper or parchment may be stained green by the solution of verdigris in vinegar, or by the crystals of verdigris dissolved in water.

Orange.—Stain the paper first of a full yellow by means of tincture of turmeric; then brush it over with a solution of fixed alkaline salt, made by dissolving ½ oz. pearlash, or salts of tartar in a quart of water, and filtering the solution.

Purple.—Paper may be stained purple by archil or by tincture of logwood. Brush the work several times with the following logwood decoction: 1 lb. logwood chips, ¼ lb. Brazil wood, boiled for 1½ hour in a gallon of water. When dry give a coat of pearlash solution, 1 dram to a quart, taking care to lay it on evenly. The juice of ripe privet berries expressed will also give a purple dye.

Yellow.—Paper may be stained a beautiful yellow by tincture of turmeric formed by infusing an ounce or more of the root, powdered in a pint of spirits of wine. This may be made to give any tint of yellow, from the lightest straw to the full colour, called French yellow, and will be equal in brightness to the best dyed silks. If yellow be wanted of a warmer or redder cast, annatto or dragon's-blood must be added. The best manner of using these is to spread them evenly on the paper by means of a broad brush in the manner of varnishing.

Rosin Size, Substitutes for. Various agents have been proposed as substitutes for rosin size. Of these "viscose" (cellulose sulpho-carbonates) calls for special attention. The necessary quantity of viscose is added to the pulp, and allowed to become thoroughly mixed; the decomposing salt, either magnesium sulphate or zinc sulphate, is then added, and gelatinous cellulose is precipitated which acts as a strong sizing agent. In most instances it is found necessary

to add a small quantity of rosin size. Papers which have been sized with viscose show a remarkable increase in tensile strength, but the slight discoloration, due to decomposition products of viscose, has up to the present time prevented its being used for the sizing of white papers.

Casein, prepared from milk, is another sizing agent which may be added in solution to the pulp, and which is readily precipitated by alum. Casein, although excellently suited for paper sizing, is but little used on account of its cost. Other sizing agents, such as silicate of soda, aluminate of soda, ammonium albumen, wax, paraffin, etc., are very rarely used.

Bleaching Paper Pulp by Electrolysis.—The electrolysis of solutions of magnesium chloride and common salt has attracted considerable attention of late years, and was first practised technically by H. Hermite. He prepared magnesium hypochlorite by the electrolysis of magnesium chloride solution. Kellner uses cylinders in which the fibrous materials are exposed alternately to the action of the products of the electrolytic decomposition of salt, namely, to sodium or sodium hydrate formed at the one, and chlorine or hydrochloric acid formed at the other electrode.

Kellner decomposes solutions in electrolysers, the electrodes of which are made of platinum-iridium, and Haas and Oettel have lately introduced an electrolyser with carbon electrodes in which the hydrogen produced during electrolysis causes a continuous circulation of the salt solution. It is claimed that the bleaching efficiency of a solution of sodium hypochlorite, prepared electrolytically, is greater than that of a bleaching powder solution containing an equal amount of available chlorine; at any rate this method of bleaching reduces the danger of the fibres being attacked to a minimum.

Loading Materials for Paper. The following mineral substances are available for this purpose :—

China clay (kaolin), which consists essentially of aluminium silicate, is the most commonly used loading material.

Pearl hardening (sulphate of lime), imparts a very superior finish to papers, and is therefore employed in the manufacture of high-class papers. Its use is, however, rather costly, owing to its solubility in water.

Heavy spar, blanc fix (barium sulphate), is one of the most useful loading materials, giving the paper very valuable properties. It may be added either in the form of a paste, or, better, it may be precipitated in the pulp by decomposing barium chloride with Glauber's salt.

Agalite, which consists essentially of magnesium silicate, possesses a fibrous structure similar to that of asbestos. It imparts a soapy feel to papers, and gives an excellent finish. Owing to its fibrous structure, nearly the whole amount of this material added is carried by the pulp.

Starch.—Starch is frequently used together with the rosin soap used in sizing; it is, however, quite safe to count it among the loading materials. A large portion of the starch added to the pulp is lost; but, although expensive, its use for high-class papers cannot be dispensed with.

The feel of papers loaded with starch is not unlike that of tub-sized papers; they do not, however, possess the characteristic water-resisting properties of the latter.

Wood Cellulose.—In the Cantor lecture before the Royal Society of Arts, Julius Hubner thus summarises the three methods of making chemical wood pulp or wood cellulose :—

The Soda Process.—In the soda process, the wood, freed from bark, knots, etc., is cut into pieces of suitable size, and is usually boiled in vertical stationary boilers with caustic soda lye, under high pressure (60 to 150 lb. per sq. in.) The boiling is followed by a preliminary washing in the boiler, and the washing and bleaching of the pulp are generally completed

in the Hollander, from which the pulp is transferred to a cylinder machine and converted into boards. The soda lye from the boiling, as well as the first wash water, are subsequently dealt with in the soda recovery plant.

The Sulphate Processes.—The sulphate processes, in which sodium sulphate and caustic soda are primarily employed as boiling agents, differ generally speaking in minor details only from the alkali processes, the construction of the plant and the treatment being in the main similar. A superior and stronger pulp is, however, obtained by the sulphate process.

The Sulphite Processes.—The use of liquid sulphurous acid proposed by Pictet has for various reasons found no practical application. Tilghman, in his patents of 1866 and 1867, describes the use of aqueous solutions of sulphurous acid for the manufacture of cellulose from wood and other fibrous materials.

As early as 1874, Ekman applied magnesium bisulphite, whilst the credit of having introduced the cheaper calcium bisulphite for this purpose is due to Dr. A. Mitscherlich, who, according to Hofmann, produced cellulose on a commercial scale by means of this process in 1874. To ensure uniform resolution of the ligno-celluloses it is essential to chip the wood, after it has been freed from bark and knots, into small pieces, and to pass these through crushing rollers and sorters. The boiling liquor, which consists of a solution of either calcium or magnesium bisulphite, is prepared by the action of sulphur dioxide on calcium or magnesium carbonate or on an aqueous solution of calcium or magnesium oxide respectively in water.

For the preparation of the sulphur dioxide required, sulphur is burned, or pyrites are roasted in specially designed ovens, which are supplied with such a quantity of air as contains the amount of oxygen required to form sulphur dioxide. After leaving the oven, the gas is cooled and washed. Large towers are used for the preparation of the bisulphite liquor from either limestone or from dolomite (magnesia limestone); these are filled with the stone, and a continuous stream of water is allowed to flow downwards whilst the sulphur dioxide enters the tower from below. The bisulphite liquor, prepared by this method, flows into a tank placed at the bottom of the tower.

The other method of preparing bisulphite liquor consists in passing sulphur dioxide into milk of lime contained in closed vessels provided with stirrers; the gas passes through a series of these vessels in succession, and the operation is so conducted as to ensure complete absorption of the dioxide, whilst the atmospheric nitrogen escapes from the last vessel.

The three principal forms of boilers, the upright stationary, the cylindrical, and the spherical rotary, are used as digesters in the manufacture of sulphite cellulose, but to protect the metal against the destructive action of the acid it is found necessary to line the boilers with an acid-resisting material. Lead was formerly used for this purpose, but has now been superseded by more serviceable materials: such as Wenge's composition, consisting of Portland cement and sodium silicate; Kellner's composition, cement, with ground slate or glass; and many others.

The time of boiling, the strength of the liquor used, and the pressure, vary considerably in the different works; whilst in some instances the wood is digested during three days at a pressure of 45 lb. per sq. in., in others the treatment is completed in one day at a pressure of 90 to 100 lb. The wood, as it comes from the digester, is still further treated in order to bring about a complete separation of the fibres, and the pulp is finally washed and bleached in the ordinary breaker. In the bleaching of sulphite wood a difficulty often presents itself in the appearance of a reddish-brown colour, which strongly resists the

action of the bleaching liquor; this may be readily avoided by treating the pulp with a solution of caustic soda or sodium carbonate as a preliminary to the actual bleaching.

Paper Testing.—Very often it will be found of importance to ascertain microscopically the kind or kinds of fibres from which a paper has been made. For the microscopical examination of papers are required a good microscope and various chemical reagents by means of which the fibres are coloured. To prepare a paper for examination, it is necessary to disintegrate it by boiling small pieces, taken from various parts of the sheet, for 10 to 15 minutes in a weak solution of caustic soda (about 1 per cent.); during this operation papers containing mechanical wood are coloured yellow. The boiled paper is now placed on a fine sieve, washed free from soda, and transferred to a bottle containing garnets. After a short shaking with water, the pulp is drained and is then ready for the preparation of the slides.

The chemical reagents used for facilitating the investigation are potassium iodide iodine solution, and zinc chloride iodine solution. On placing a few drops of the former on a small quantity of the pulp placed on a slide, the principal fibres show the following colouring: Linen, cotton and hemp—light to dark brown. Straw and jute cellulose—grey. Wood cellulose and esparto—partly grey, partly brown. Manila hemp—partly grey, partly brown, partly yellowish brown. Wood pulp (mechanical) and raw jute—partly yellow, partly yellowish brown.

Zinc chloride iodine solution gives the following reactions: Cotton, linen and hemp—claret red. Wood, straw, esparto, and jute cellulose—partly blue, partly reddish and bluish violet. Manila hemp—blue, bluish violet, dull yellow, and greenish yellow. Wood pulp and raw jute—lemon to dark yellow.

Before applying zinc chloride solution, the pulp must be freed from water by squeezing it on a porous plate. The fibres have to be separated with a pair of platinum preparing needles and then covered with a thin cover-glass.

Considerable experience is required in working with the microscope, and a careful study of the structural characteristics of the different fibres is essential.

Cotton fibres appear under the microscope as flat ribbons, usually twisted upon themselves. The flax fibre appears round and fairly regular, and shows a distinctly visible narrow central canal. Numerous dark lines run cross-ways, and are due to pores in the fibres. The so-called linen bulbs are very characteristic widenings of the fibre. Hemp fibres, as present in papers, cannot be distinguished with certainty from flax fibres. Mechanical wood shows a ragged torn appearance, and its structure is not a fibrous one. The pitted vessels or pores, which appear in the shape of two concentric rings, are very plainly visible. Cross markings on many of the wood cells may also be frequently noticed. The bast fibres of jute are distinguished by a distinctly visible canal, the width of which varies considerably. In some places it is completely obliterated, and appears as a single line.

Wood cellulose fibres are usually flat, often twisted and not unlike cotton. In many instances the characteristic rings as seen in the mechanical wood are plainly visible in the cellulose.

Straw fibres are round and smooth and accompanied by numerous cuticular cells, some of which are very wide and flat whilst others are peculiarly marked and serrated. The spiral shaped cells carry a ring at each end, and although the cells are mostly torn the rings may be always found in straw papers.

Esparto fibres and cells are very similar in appearance to the straw fibres and cells. The characteristic small pear-shaped hairs or cells, which are always found in esparto papers,

afford, however, a ready means of distinguishing esparto from straw.

To ascertain the respective quantities of fibres present in a paper, it is necessary to compare the microscopic preparation with fibre mixtures of known composition. Very considerable experience is, however, required to obtain results possessing a high degree of accuracy.

The thickness of a paper may be ascertained by using one of the ordinary micrometer arrangements, such as those of Schopper, Rhese and others, by means of which measurements may be conveniently made to within 0·001 mm.

Before proceeding with the testing of machine-made papers, the machine-way and the cross-way of the paper respectively must be ascertained. Both methods used are based on the assumption that the fibres in the machine-way are more closely felted than in the cross-way.

Valuable conclusions may be drawn from the results of determination of the resistance which a paper offers to tearing. Papers which have to be tested should be kept for some time in a room the air in which contains a known percentage of moisture, as the results are considerably influenced by atmospheric conditions. Strips, 15 mm. in width, are then cut length-ways and cross-ways from different sheets.

The chief tearing-machines used in paper-tearing are those of Schopper, Hartig-Reusch-Leuner, and Wendler. In Schopper's type, the strip of paper, 180 mm. in length, is suspended vertically between two clips, and, by means of a simple hydraulic device, the load is gradually increased, until the strip breaks. The breaking load and the elongation are indicated on two scales.

In the Hartig-Reusch-Leuner type of machine, tension is put on the strip by means of a steel spring, and the breaking load as well as the elongation are given in the form of a curve, the apparatus containing an automatic registering device.

The Wendler tearing-machine, in which the load is increased by means of a spring, differs from the last named in that the breaking load and the elongation are indicated on separate scales.

The tensile strength of papers may be very conveniently expressed by giving the length of a strip of paper which, if fastened at one end and allowed to hang free, would break by its own weight. The width of the strip is immaterial.

The resistance which a paper offers to crushing, rubbing, and folding, may be considered as next in importance to its resistance to tearing. Although a paper may be quite good as far as tearing is concerned, its resistance to rubbing, etc., may not necessarily be so satisfactory. Tests of this kind have until lately been exclusively made by hand, a method the results of which obviously depend much upon the individual by whom the tests are made. Schopper has constructed a special machine for this purpose which has been found to give reliable comparative results. By means of a crank shaft, provided with a slit, the strip of paper is folded backwards and forwards until it breaks. A counting device indicates the number of times the strip has been folded.

The amount of ash which a paper contains depends to some extent upon the kind of fibres which have been used in the manufacture, because the amount of natural ash of the fibres varies considerably. Thus, white linen contains about 0·2 per cent. of ash, whilst adansonia yields about 7 per cent.

The quantity of ash in a paper is ascertained by incinerating a weighed piece of the paper in a skeleton cylinder made of strong platinum wire. The residue is weighed either on a chemical balance, or on Post's or Reimann's ash balances which are specially adapted for this purpose.

In examinations possessing a high degree of accuracy, chemical changes which may occur during incineration

must be carefully taken into consideration.

Rosin size in a paper may be readily detected by boiling a small piece with glacial acetic acid and pouring the product into distilled water. The water will become opalescent if rosin size is present. The presence of starch in a paper is ascertained by means of potassium iodide iodine solution, with which the characteristic blue coloration is obtained.

An excellent reagent for animal or tub-size is Millon's reagent, i.e. mercuric nitrate. Tub-sized papers, if moistened with this solution and slightly warmed, turn pink or red.

Papers which are used for special purposes, as for instance, for the wrapping of polished steel and other articles, should be carefully examined for free chlorine and for free acid. A quantity of the paper is extracted with boiling water and the extract tested for free chlorine with potassium iodide starch paper and for acid with Congo red solution, a colouring matter which turns black with free acids.

The ink and water resisting qualities of papers are tested by means of solutions of ferric chloride and pure tannic acid, which, when mixed, produce a black colour lake. The ferric chloride solution is applied to one side, the tannic acid to the other side of the paper. Penetration and consequent contact of the two solutions will be impossible if the paper is hard sized, whilst the grey or black discoloration will rapidly appear on soft sized papers.

The presence of mechanical wood in papers may be detected by the characteristic reaction with solutions of aniline sulphate (yellow), naphthylamine hydrochloride (orange), and phloroglucinol (magenta, red). The quantity of mechanical wood can be ascertained with a certain degree of accuracy, by comparing the depth of colour produced with that given by paper of known composition.

PAPER-HANGING.

(*See also* PASTE, under "Cements.")

(a) Wall-paper is sold by the piece (roll), those of English make being 12 yards long by 21 in. wide (therefore containing 7 square yards), while the French papers, of which there is a large number on the market, are usually 9 yds. long by 18 in. wide ($4\frac{1}{2}$ sq. yds). The French papers, however, are not invariably of this size, and in consequence whenever paper is being chosen its size must be at once noted. In the pattern books of papers the size is usually given at the back of all the different designs, for these books may contain mixed makes and sizes. The embossed sheet materials known as Lincrusta-Walton and Anaglypta, which can scarcely be called papers, are made in various sizes and are bought in any quantity required. Paper friezes, borders and extras of this kind are bought by the yard, though dados are sold by the piece the same as ordinary papers.

A point well worth remembering, especially when it is difficult to get a frieze to suitably match a paper—as not infrequently happens—is that some papers (fillings) make excellent friezes when cut into two or three strips lengthways, and it will be found that this is a cheap plan, for frieze papers are always expensive compared to fillings. It is commonly a French paper that suits best for this, as they make striped designs in which the "stripe" is really a band or ornamental line of flowers, a succession of wreaths, bouquets, etc., which makes a dainty frieze for bedrooms or ladies' reception rooms. When the filling paper in a room is at all rich in design, a frieze of perfectly plain paper in suitable tint serves better than a design. Again, a frieze may be best in Lincrusta-Walton or Anaglypta, this being painted a suitable tint and perhaps picked out in a different tint or colour. At the time of writing the

"dado" has gone quite out of fashion, being seldom seen except in business premises. Even in these places it is generally of material like Lincrusta, or of wood, to resist rough usage and to bear washing.

(*b*) If the walls are quite new and smoothly finished, the only preparation usually necessary is to lay on a thin coat of size—the use of the size being to make a surface to which the paper will stick better than to the bare wall. In good work a specification will commonly say "twice size the walls," it being considered that once sizing is not always sufficient. It depends on

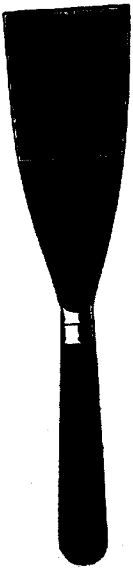


FIG. 94.

the walls. In preparing an old white-washed or coloured wall for paper, the wash or colour is wetted with water and scraped off with a suitable tool as Fig. 94, or any piece of steel which has a smooth edge, after which the wall should be rubbed down with a stiff brush, to remove all that the scraper may have left, and make an even surface. In some cases the walls are finally rubbed down with coarse sand-paper. If there is any loose plaster, those parts should be well sized and have a piece of thin strong paper pasted over them; but the best way is to have the place replastered. Cracks or holes may easily be filled with a little plaster and whiting; in no case should they be left. If not stopped in any other way, slips of paper should be pasted over them, or else the cracks will soon show through the outer paper. After all this is done, the room may be sized, and when the size is dry enough the papering is commenced. If the room has been already papered, the old paper may be soaked and cleaned off, or, in cheap work, it is only necessary to go over the walls and tear off all the loose pieces, especially at the top and bottom, corners, and edges. If the bare wall is exposed by the tearing off, these spots should be sized. The walls of rooms finished in a superior manner are generally plastered three coats; and upon the plaster, when quite dry, a coating of lining-paper is laid, to obtain a smooth surface. Sometimes common thin canvas ("scrim") is used instead of lining-paper, and occasionally instead of plaster. In the latter case, battens should be fixed against the walls, to fasten the canvas to, and prevent it touching the walls.

The preparations having been made, the hanging of the paper may be proceeded with: the rule is, that the edges of the paper, when hung, shall be towards the window. The appearance of many a handsome paper has been spoiled from carelessness or ignorance in this particular; but when this precaution is observed, the lapped joints scarcely show. First of all, the edges of the paper are to be cut, and as the hanging is to begin at the window on each side, that edge which is cut close for one side must not be cut

close for the other, unless "butt joints" are specified, though even in this case a very narrow lap is allowed. This point being decided, unroll a yard or two of one of the pieces of paper, cut the edge, unroll a yard or two more, roll up loosely the part that is cut, and continue till the end is reached, when, the process being repeated with the other edge, the piece will be at last rolled up again as it was at starting. Not more than about ¼ in. of paper should ever be left at the edge which is not cut close. If there is a back and a front window in the room, the same rule must be observed and the finish will come in the corner most out of sight, by the mantel-piece or at the back of the folding doors.

When the edges are finished, the paper is to be cut into lengths, about ¼ in. longer than the height of the room; but they must be cut so that the second will match the first, and so on, and if the length required comes between the pattern, the portion down to the next must be cut off after each length, which will bring the match the same as where it started in the first length. Care should be taken to cut straight across, and as many lengths may be cut as will be sufficient for two sides of the room. These are to be turned all together the plain side uppermost, and the first one may be pasted. If the paper is thin and common, it must be put on the wall immediately; but if of good quality, it is to be left to soak for two or three minutes, while for a stiff glazed or flock paper from five to eight minutes would not be too much. The reason is, to give time for both sides to become equally damp, otherwise there is no certainty that the paper will stick. The first length is to be put up with the close-cut edge close to the wood-work round the window. Having brought the top to meet the ceiling, see that the length hangs straight, trying it if necessary by a plumb-line, then taking it by the lower end, lift it away from the wall all but about 3 in. at the top, then let it fall, and it will drop into its place without a wrinkle. Now with a soft clean cloth begin at the top and press the paper to the wall all down the centre to the bottom, then beginning from the top again, press it from the centre to each side alternately, regularly downwards. If this operation be properly done, the length will be perfectly close to the wall and smooth in every part. It is not to be pressed heavily; but the cloth being taken in the hand, as a round loose lump, must be moved quickly over the surface with a light and clean touch, otherwise some of the colours will be apt to smear. A soft hair brush, as Fig. 95, is commonly used

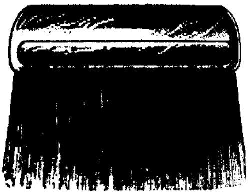


FIG. 95.

for the purpose, there being less likelihood of smearing even with common papers. Last of all, mark with the end of the scissors where the paper meets the skirting, cut off all that is over, and press the end carefully into its place. Proceed with the second length in the same way, bringing the close-cut edge to meet the pattern of the first one, and taking care that no gap is left between. Neglect of these precautions will convert a handsome paper into a sight that will be a constant eyesore. Try the lengths frequently with the plumb-line, to avoid the chance of getting out of upright, and remember that the outside end of the piece is always the top of the paper. With papers that the cloth lightly applied, or the brush, will not press down sufficiently, a paper-hangers' roller, as Fig. 96, is used. Fig. 97 shows a roller for angles.

Paste is best made with flour (pre-

ferably old), water, and a little size or glue; alum is also added to paste to make it spread more freely without losing any of its tenacity or sticking quality; it should never be used while

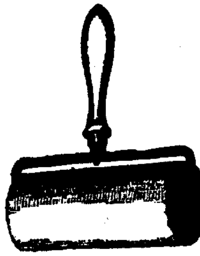


FIG. 96.

FIG. 97.

warm. The paste should be rather thicker than ordinary guel, and laid on smoothly and equally, not putting too much, or it will squeeze out at the edges. Where this takes place, it must be removed with a clean damp sponge: any accidental smears of paste may be removed in this way, if taken off lightly as soon as they are made.

(c) **Papering Ceilings.**—In papering a ceiling with lining-paper, it is better that the edges of the lengths should barely meet than that they should overlap. In cutting ceiling-papers to the angles formed with the wall, the less they are allowed to lap on to the wall the better; ¼ in. or so is quite sufficient, because when a couple of thicknesses of paper are on such places they generally "spring" unless they are very strongly attached.

If there are any cracks in the plaster they need even more attention than in cases where distemper is to be applied direct to the ceiling. In stopping a crack the object is not only to fill it up. With cracks in ceilings generally, one edge will be found to be slightly drooped. In this case the crack requires to be cut out before stopping. If it were not, after lining it would show as a sharp, irregular edge. The only remedy is to enlarge the crack, more or less, according to its importance, by scraping or cutting it out with a stopping knife. For stopping large cracks a stopper—a knife with a blade about 3 in. wide—is a very serviceable tool. It might be worth while remarking here that where walls or ceilings are to be finished in distemper, without previous papering, it is best in stopping, to discard steel knives, which scrape and disfigure the face of the plaster in a way which invariably shows through the subsequent mat of distemper. Use, instead, a tool made of wood and shaped like a stripper, and use it in the same way. As to the stopping, it is generally made of plaster-of-Paris, with whiting added. Sometimes, when convenience renders it necessary, some add a few drops of size to the mixture, to prevent its too rapid setting. It is surprising, to one not familiar with it, what an effect the addition of size has; but, at the same time, it is generally considered that the stopping is better without this addition. Always wet cracks, etc., thoroughly before putting in the plaster, otherwise it will not adhere for any length of time.

But to return to the paperhanging. In lining a ceiling, start the paper from the wall nearest the window, and work towards the door. The reason of this is that, if there should be any overlapping edges, they will be facing the window, and therefore not visible from the door or main part of the room—that is, in a room of ordinary shape. If, on the other hand, the paper were hung to the window, overlapping edges, which, even with the most careful workmen, are bound to occur, throw a shadow line, which, under usual conditions, would be almost certain to catch the eye.

In papering a ceiling, proceed in the same way as the walls. Find the length of the pieces of paper to go from wall to wall, and cut the number required. Arrange a scaffold so as to have the plank running close up to and parallel with the wall to which the first length is to be hung. Ceiling lengths are generally longer than a wall requires. Fold them with a long fold at the top—or starting end—and a very short fold at the bottom or finishing end.

The first length has no previous one to match to. We shall, therefore, for convenience sake, consider it hung, and will describe the manner of getting the second up, which description will apply equally well to all those that follow. And first as to pasting. In this, as a rule, there is not much variation necessary, except when the lengths are very long. Say men are on a moderately-sized room. Make the first fold as large as the board will allow, and the bottom end one much smaller. The next operation is to hang it. In hanging ceilings a roll or portion of a roll of paper is necessary as a support to the pasted lengths. Insert this roll beneath the top portion of the pasted length on the board, and lift and carry it on the roll to the scaffold. Have the plank running parallel with the length previously hung, and have the inside edge of it directly under and in a line with the outer edge of the last length hung. This is important in order to be directly under one's work. Do not have the scaffold too high, but sufficiently low to allow the body, arms and eyes full play. Start from the right-hand wall with your back to the last length on the ceiling. With the right hand take hold of the extreme corner of the length by the inside edge. Now open the first fold and move the supporting roll about until we have 2 ft. or 3 ft. between the two hands. If we succeed in placing these 2 ft. or 3 ft. on the ceiling correctly, the remainder of the length, however long, if the ceiling be true, will find its place almost as a matter of course.

Hold the length up to the ceiling, with arms outstretched, and work it about, within an inch or so of the ceiling until we have settled the correct place in which it is to go—but do not, on any account, allow it to touch yet—and, when this is settled, with the right hand match and place the near-end corner. Now we have to see to the portion directly over the supporting roll held by the left hand. Though the right hand should not be allowed to shift yet, it must be used as a pivot for the portion over the left hand to be correctly worked into place. When the edges of the space between the two hands match correctly, temporarily press the roll on the ceiling, run the right hand along the edge, to fix the match, and then, still holding the roll in the left hand, firmly against the ceiling, take the brush from the pocket and brush down the first foot or two of paper. If the length be correctly started in this fashion, all we have to do is to move the supporting roll along under the paper, a foot or more at a time, and brush down by a brush stroke on the middle of the length, followed by others towards the edges, keeping the roll in the left hand always an inch or two away from the ceiling.

If the first foot or so of edge is perfectly parallel with the edge of the previous length, the whole length will brush into its place without the least trouble. But if the edge over the left hand is the least bit overlapped, whilst correct at the extreme starting point, it will mean that the overlap will gradually increase as the length is brushed on, until at the finishing end it may be a ¼ in. or more overlapped, and the whole match consequently bad. If, on the other hand, it overlaps slightly at the extreme starting-point, and is just where the supporting roll is, it will be found that before many more feet of the paper are brushed on the edges of the length previously hung and of that being hung will appear to be growing gradually wider apart, leaving a considerable space of the

ceiling bare, and necessitating either that the length be taken off and re-matched or else subjected to a considerable amount of brushing and twisting, which will have to be repeated in hanging subsequent lengths.

Never allow the pasted side of the paper to touch the ceiling until it is brushed into its place. Keep the roll supporting the pasted length always a few inches away from the ceiling. When we come to the small end fold, however, the roll may be temporarily placed firmly against the ceiling whilst the fold is being undone.

Papering a large ceiling is really little more difficult than doing a small one, the only extra trouble being in handling the large body of pasted paper. But the secret of success is to correctly match the first foot or two. The method of folding the pasted lengths needs to be varied somewhat. The method generally adopted by the best paper-hangers I have known is rather difficult to describe, but is as follows: Paste and fold the first part resting on the board, but partly unfold it back until the extreme end rests on the turning point of the large fold. The first long fold is, in fact, half unfolded again. This gives us two short folds with a portion of the pasted side upward. Draw the length along, and paste, fold and again half unfold this second portion. These short half-folds may be continued as long as necessary, the final fold being an ordinary short fold in the opposite direction. Now, to hang the length, place the supporting roll directly under these numerous half-folds. The left hand, with the roll, supports the pasted fold, which must not be allowed to touch the ceiling, whilst the right hand is at liberty to fix the matching edge in its place and then brush the paper down, the short folds on the supporting roll gradually unrolling of themselves as the operator moves along the plank. ('Painters' Magazine.')

Fixing Anaglypta or Lincrusta-Walton.—In trimming this material scissors may be used with light qualities, but a metal (or metal-edged) straight-edge and a keen knife, like a shoemakers' knife is more usually requisite. First paste the back of the material with ordinary paper-hangers' paste, and let it stand 20 minutes; then re-paste it with paper-hangers' paste, with which is mixed one-fourth fluid glue, and put it up at once. A soft cloth is used for pressing Anaglypta as a roller would injure the high parts of the pattern, but this is not the case with Lincrusta in which the design is solid. Another method, if it appears suitable, is to first paper the wall with brown paper, then attach the embossed material with ordinary glue. A good plan with any method of fixing is to let a 2-in. strip of muslin come behind each joint to prevent it opening. Lincrusta sometimes requires to be damped at the back before hanging, and fine pins are often necessary at the angles.

Stripping Walls.—If a little soda or lime is put in the water the paper is more easily removed. If a disinfectant is thought desirable, wash down the walls with dilute caustic soda. Repair all bad places in the walls with plaster and whiting. The walls should be sized (in good work) even though a paper has been on before. Lining-paper is required to make a sound job on a poor wall.

Strong Paste for Damp Walls. Soak a ¼ lb. glue in water for a day, to make it swell, then dissolve in half a pint of boiling water. When dissolved, but still hot, stir in 2 oz. Venice turpentine. Make some ordinary flour paste, 1 lb. of flour to 1 pint of water, and when ready stir in the warm glue solution. Thin the whole down with about 2 quarts of boiling water, stirring well.

Sizing and Varnishing Wall-Papers.—(a) For a moderate sized hall and staircase, dissolve 7 lb. of size in 3 gal. of boiling water. When this has become cold it will be like very weak jelly. Apply with a whitewash brush, being sure that no part of the

paper is missed. A second coat is necessary the following day. When this is dry (about 24 hours) the varnish is applied. The varnish may be made up of equal parts of pale oak varnish, turpentine and raw linseed-oil, say two quarts of each. Use a hog-hair varnish brush, and work downwards.

(*b*) For Fancy paper. Make a size of isinglass dissolved in warm water, and when it is cool go over the paper lightly and carefully with a camel-hair brush; do not go over any part twice, yet see that all is covered. When dry go over again. For immediate use a varnish may be made by warming some Canada balsam until it is quite liquid, then adding an equal quantity of turpentine, shaking well; let stand in a warm place for 12 hours, then use. If time will admit, other varnishes may be made and used (*see* "Varnish for Wall-Paper"), but these take several days to prepare.

(*c*) Sizing and Varnishing Sanitary Paper. First wash the paper with warm water to which a little ox-gall has been added (¼ gill to the quart), then make a size of ½ lb. best glue dissolved in 2 gal. of water and apply this. Allow one day to dry. Varnish with one quart of Kauri varnish, to which has been added 1 pint of turpentine and 1 pint of raw linseed-oil.

Varnish for Wall-Paper.—Put 1 lb. of dammar and 1 lb. of mastic in 2 quarts of turpentine, and let them dissolve without heat. Or put 2 lb. sandarach (gum) in 12 oz. turpentine to dissolve (this will take about 2 days if shaken occasionally), then add 3 quarts of methylated spirit. (*See also* three preceding Recipes.) A good varnish may be made by taking 5 oz. sandarach (gum) and 1 dr. of camphor, crushing these fine, and putting them in 1 pint of spirits of wine. When dissolved, which will take a few days with occasional shaking, add ¼ lb. Canada balsam. Mix thoroughly, and strain or filter; or it will suffice if the whole is allowed to settle and the clear part poured off. Keep well corked as the chief ingredient, the spirit, will evaporate. Sizing, two coats, always precedes varnishing, ordinary size being used, or, what is better for delicate work, gelatine or isinglass dissolved in warm water.

Varnishing cannot be properly done in cold or damp weather. The temperature should not be less than 60° F.

Patching Old Wall-paper with New.—If the paper on a wall receives an injury that may be repaired by patching with a piece of similar paper, a difficulty arises from the fact that the old exposed paper has taken a different hue to the piece that has been freshly unrolled. As a rule the old paper is darker than the new, and to make them match the new piece, after it is pasted on and dry, must be washed over with a colouring agent. A weak solution of ordinary size is sometimes sufficient to tone down the new colours, failing which a little colour stain may be added. It is best to try the effect on a spare piece of paper first, especially to see if the colours will run or not.

Measuring up for Wall-papers.—Those who are used to the work almost always guess the number of pieces required, but the less experienced must have recourse to measurements. It is not difficult to measure round the walls, in feet, and divide by 1¾ to find the number of cut lengths required, reasonable allowance being made for windows and doorways. It is in cutting the lengths that a variation occurs, not only in the distance from the skirting to the cornice (or frieze or picture rail) but also in the amount of waste due to the pattern. With some papers, plain stripes for instance, there is no waste, but in all floral and other designs there must occur some waste, and the rule is to allow one in ten for this for small patterns and one in seven for large patterns.

PAPIER-MÂCHÉ.

(*See also* JAPANNING, PAPER-MAKING, PICTURE FRAMING, STEREOTYPING, ETC.)

(*a*) For papier-mâché furniture the following method of manufacture is followed. The pulp is prepared, consisting for the most part of waste papers broken up in the engine, and run into drainers. This half stuff is then taken and moulded into the required form, and after drying is varnished and polished. Articles made in this way are termed papier-mâché, and very light and durable tables, chairs, trays, and numberless other articles of furniture, are produced at very small cost. The principal objection to this substance is that it has not the same power of retaining a firm hold of nails, screws, etc., which is possessed by wood, so that for articles requiring hinges or other similar arrangements it is not so suitable. It may be turned in a lathe or moulded to any shape in the condition of pulp, so that it is very suitable for articles made in one piece only; it is also susceptible of a considerable amount of ornamentation by inlaying with mother-of-pearl and other substances, which is easily done when the article is in the damp soft state.

(*b*) Papier-Mâché. Articles, so named, are produced by pressing the pulp of paper between dies, or by pasting paper in sheets upon models. The articles when dry are varnished, japanned, and ornamented. By the first method, a variety of cheap articles is manufactured in Paris; the materials for the pulp, viz. paper and paste, being supplied by the bill-stickers, whose bills having served the purposes of advertisement, are pulled down and taken to the factory, mashed in water, and pressed in moulds. The second method is the superior of the two, and is thus conducted at Birmingham: Paper of a porous texture, saturated with a solution of flour and glue, is applied to an iron, brass, or copper mould, of somewhat smaller size than the object required; repeated layers of this paper are put on with glue, a drying heat of 100° F. being applied after every new coat. When a sufficient thickness is attained, the shell is removed from the mould, and planed and filed to shape. About 10 layers are used for ordinary tea-trays, more or less for other articles, according to requirements. A stoving varnish mixed with lampblack is next laid on, and the article is stoved. Several coats of varnish are added, with a stoving after each (*see* JAPANNING). When sufficiently covered with this preparation, the inequalities are removed with pumice-stone, and the artist applies the ornament in bronze-powder, gold, or colour. Several coats of shellac varnish are then put on, and the article is stoved at a heat of 280° F. The surface is polished with rotten-stone and oil, and brought to a brilliant gloss by hand rubbing.

(*c*) Papier-mâché used for decorative purposes is prepared by laying sheets of brown paper one over the other, with a coat of glue between every two layers. This mass of paper is pressed into a metal mould of the ornament required; the moulded paper being trimmed to shape, a composition of the pulp of paper mixed with rosin and glue is put into a mould in a thin layer; the paper is again inserted and pressed upon the pulp composition which adheres to it, and produces a sharp well-defined ornament.

(*d*) Two modes of making articles of papier-mâché are adopted, either by gluing or pasting different thicknesses of paper together, or by mixing the substance of the paper into a pulp, and pressing it into moulds. The first mode is adopted principally for those articles, such as trays, in which a tolerably plain and flat surface is to be produced. Sheets of strong paper are glued together, and then so powerfully pressed that the different strata of paper become as one. Curvatures may be given while the material is

damp, by the use of presses and moulds. Articles such as snuff-boxes are made by gluing pieces of paper cut to the size of the top, bottom and sides, one on another, round a frame or mould, which is afterwards removed.

Articles made of pasteboard have a fine black polish imparted to them in the following manner: After being done over with a mixture of size and lampblack, they receive a coating of a peculiar varnish. Turpentine is boiled down until it becomes black; and three times as much amber in fine powder is sprinkled upon it, with the addition of spirit or oil of turpentine. When the amber is melted, some sarcocolla and more spirit of turpentine are added, and the whole is well stirred. After being strained, this varnish is mixed with ivory-black and applied in a hot room, on the papier-mâché articles, which are then placed in a heated oven. Two or three coatings of the black varnish will produce a durable and glossy surface, impervious to water.

(c) Papier-mâché, properly so called, is that which is pressed into moulds in the state of a pulp. This pulp is generally made of cuttings of coarse paper boiled in water, and beaten in a mortar till they assume the consistence of a paste, which is boiled in a solution of gum arabic or of size to give it tenacity. The moulds are carved in the usual way, and oiled, and the pulp is poured into them, a counter-mould or core being employed to make the cast nothing more than a crust or shell, as in plaster casts. In some manufactories, instead of using cuttings of made paper, the pulp employed by the paper-maker is, after some further treatment, poured into the moulds to produce papier-mâché ornaments.

Papier-mâché has now, in some cases, superseded the carved and composition ornaments employed to decorate picture and glass frames; but it is in the ceilings and walls of rooms and the interiors of public buildings that papier-mâché is found most valuable. Plaster and composition ornaments are ponderous; carved ornaments are costly; but those of papier-mâché are light and of moderate price. Maps in relief are also occasionally made of papier-mâché. Paper roofs have been occasionally used. Sheets of stout paper are dipped in a mixture of tar and pitch, dried, nailed on in the manner of slates, and then tarred again; this roof is waterproof, but unfortunately very combustible.

Paper Casts from the Antique.—This method of obtaining facsimiles of sculpture in basso-relievo is very easy. Stiff, unsized, common white paper is best adapted for the purpose. It should be well damped; and, when applied to sculpture still retaining its colour, not to injure the latter care should be taken that the side of the paper placed on the figures be dry—that is, not the side which has been sponged. The paper, when applied to the sculpture, should be evenly patted with a napkin folded rather stiffly; and, if any part of the figures or hieroglyphics be in intaglio or elaborately worked, it is better to press the paper over that part with the finger. Five minutes is quite sufficient time to make a cast of this description; when taken off the wall, it should be laid on the ground or sand to dry.

Carton-pierre ornaments are also composed of the pulp of paper mixed with whiting and glue, pressed into plaster piece-moulds backed with paper, and, when sufficiently set, hardened by drying in a hot room. Carton-pierre ornaments are stronger and lighter than those made of plaster-of-Paris.

PARCHMENT.

Natural.—(1) In making natural parchment, the pelts, after liming, washing, and fleshing, as for leather-dressing, are split by the splitting-machine, and the inner layer is taken for making parchment. Knots are made in the edges of this layer by tying up portions of lime or rubbish into balls all round, and by these knots the skin is stretched upon wooden frames. Whilst on the frames, the split side is scraped to render it even, and the skin is then "dubbed" with whiting and a strong solution of soda-ash to get out the grease. Next it undergoes a series of scaldings with hot water thrown upon it out of a bowl, of scrapings, and of washings with whiting and water, and is finally dried in a warm chamber. (Ballard.)

(2) To make parchment transparent, soak a thin skin of it in a strong lye of wood-ashes, often wringing it out till it becomes transparent; then strain it on a frame, and let it dry. This will be much improved if, after it is dry, it receives a coat on both sides of clear mastic varnish, diluted with spirits of turpentine.

Artificial.—(1) Strong unsized paper is immersed for a few seconds in oil of vitriol (concentrated commercial sulphuric acid), diluted with half its volume of water. It is then washed in pure water or weak ammonia water. It strongly resembles animal parchment, and is used for the same purposes. The acid solution must be exactly of the strength indicated, and not warmer than the surrounding atmosphere.

(2) Another method consists in using the commercial oil of vitriol in an undiluted state. The paper is first passed through a solution of alum and thoroughly dried previous to its immersion, thus preventing any undue action of the corrosive principle of the vitriol. After the application of the acid, the paper is passed into a vat of water, and then through an alkaline bath, to be again washed. Written and printed paper may undergo this process without materially affecting the clearness and distinctness of the letters, and the paper retains all its qualities, even after being wetted several times in succession; while paper prepared in the usual manner loses, to a great extent, its pliancy, and becomes hard and stiff.

(3) By immersing cellulose for a few seconds in a perfectly cold mixture of 2 parts oil of vitriol and 1 of water, although no alteration of its chemical constituents takes place—except perhaps a purely molecular one—its physical characteristics are greatly changed, it being converted into a leather-like body of great comparative toughness. White unsized paper—itself a tolerably pure form of cellulose—thus treated, goes by the name of "parchment paper," and its tensile strength is increased to some 40 or 45 times that of the original paper used. This form of cellulose is especially well adapted for many purposes in medicine and pharmacy, including "caps" for jars and bottles, sample envelopes, labels, "untearable tallies," and even certain forms of surgical bandages. By treating "parchment" or "Gaine's" paper—as it is sometimes called from the name of its inventor—with a little hot strong solution of gelatine, to which about 2½ or 3 per cent. of glycerine has been added, and allowing it to dry, it may be rendered tolerably impervious to fatty matters, so that it then forms a convenient medium in which to pack small quantities of such substances as ordinarily are apt to soil the paper they are wrapped in. The same altered variety of cellulose, if soaked with benzol or carbon bisulphide holding 1 per cent. of linseed-oil and 4 of indiarubber in solution, makes, when dry, an admirable and inexpensive waterproof envelope for the preservation and transport of drugs and deliquescent salts. By using an envelope of this description, closing it carefully (when filled) with a little stronger solution of caout-

chouc, and afterwards placing the same inside a similar one of large size containing fine oven-dried oatmeal, even calcium chloride and crystals of ammonium nitrate have been forwarded in damp weather without their having attracted moisture, or suffered any appreciable change during transit. ('Monthl. Mag.')

Removing Wrinkles. — When parchment documents are wrinkled and creased, the evil may be remedied, without injury to the writing, in the following manner: Place the document, face downward, upon a clean piece of blotting-paper. Beat up to a clear froth, with a few drops of clove-oil, the whites of several fresh eggs, and with the fingers spread this over the back of the sheet, and rub it in until the parchment becomes uniformly soft and yielding. Then spread it out as smoothly as possible, cover it with a piece of oiled silk, put on it a piece of smooth board, and set it aside in a cool place, with a weight on the board, for 24 hours. Then remove the board and silk, cover with a piece of fine linen cloth, and press with a hot smoothing-iron (not too hot) until all signs of wrinkles have disappeared. The heat renders the albumen insoluble, and not liable to change.

Staining Parchment.—(*See* STAINS AND STAINING.)

PARQUET FLOORING.

PARQUETRY, or parquet-flooring, is composed of pieces of various coloured woods, such as cherry, walnut, oak, ebony, mahogany, maple, etc., laid to some regular—generally geometrical—design, on a perfectly sound and even floor. Before the parquetry is laid, the floor is carefully traversed or cross-planed that it may be made level and regular. All nail-heads are punched in and any large joints filled up.

There are now a considerable number of patented arrangements for inter-locking each piece of the parquet covering, some adapted for wooden floors, but more for cement and mastic floors to which the pieces could not be glued or nailed. The following does not relate to these, but simply describes the method of fixing the pieces when they are quite plain and possibly prepared in the joiner's own workshop. In the latter case too much stress cannot be put on the importance of accuracy in preparing the pieces, both in size and form, otherwise it will be impossible to keep the design uniform.

Assuming that the floor is prepared and carefully brushed free of shavings and dirt, it is customary to lay the border first, if there is one. This can be made to bring any small breaks or irregularities along the wall, into a straight line. After this the work is commenced in a corner, either a conspicuous corner or an inconspicuous one, according to how the design is expected to work and finish. When there is to be a special design in the centre, it is the common plan to work from the corners to this, as it is usually found to be easier to correct irregularities in such a centre than at the edges.

Assuming it is thick parquetry, the pieces being ¾ in. to 1 in. thick, the customary plan is to glue these to the floor and to each other, and to nail the larger pieces down by thin wire nails driven at an angle through the

edges. If not nailed they should be dowelled with ¼ in. dowels, but neither is considered necessary with the small pieces of the design. The glue should be strong and hot, and freely applied to both surfaces, i.e. to each block and the floor. A vessel of hot water and a cloth should also be alongside to wipe any glue from the face of the parquet. When all is down it should be left one night (12 hours) to get dry and hard, then cleaning is done as may be required, finally scraping and papering with medium, then fine, glass-paper.

Thin parquet, the wood being usually ¼ in. thick, is made up into squares or repeats on the bench from 12 in. to 16 in. in size. The pieces have a fine saw groove run round all the edges, and a thin cross tongue of hard wood inserted. The pieces are then put together face downwards and a sheet of tough paper or fine canvas is glued on the back. These panels, when sufficient are ready, are laid as a solid piece, glued to the floor and to the surrounding pieces. They are cleaned off, scraped and glass-papered, the same as the thicker pieces.

PAVEMENTS.

(*See also* CONCRETE AND TILE-LAYING.)

Asphalt.—The general process followed in laying asphalt pavements is first to make a solid foundation of lime or cement concrete, 5 in. to 8 in. thick, according to the traffic expected, and finish this smooth on top about 2 in. below the level the finished pavement is to be. The asphalt is a mineral substance, and is commonly used in its pure state without admixture of any foreign matter. It is first broken into small lumps, and is then brought to a state of dry powder by subjecting it to considerable heat in revolving ovens; it is then put into iron carts with close-fitting covers, and brought on to the works, taken out, laid over the surface, and whilst hot compressed with heated irons into one homogeneous mass without joints. The finished thickness varies from 2 to 2½ in., according to the traffic of the place in which it is laid, and it further compresses and consolidates under the traffic.

Val de Travers Liquid Asphalt is laid upon a concrete bed 6 in. thick, the asphalt surface being 1½ in. thick. The rock is first ground to a fine powder, and being then placed in caldrons, from 5 to 7 per cent. of bitumen is added to dissolve it; heat being then applied, it forms into a semi-fluid or mastic state, and when in that condition about 60 per cent. of grit or dry shingle is added to it, and after being thoroughly mixed together, the compound is spread over the concrete in one thickness.

With *Limmer asphalt*, a concrete foundation 9 in. thick is first formed, and the asphalt is used in certain proportions by the judgment of those directing the work; it is broken up and mixed with clean grit or sand of different sizes according to the place in which the pavement is to be laid; a small quantity of bitumen is then

added to the materials, which are placed in caldrons on the spot, made liquid by heat, and the compound is run over the surface and smoothed with irons to the proper slopes and curvatures. It is run in two thicknesses, the lower stratum being made with grit of a larger size than that of the upper. The total thickness of the asphalt, when finished, is from $1\frac{1}{2}$" to 2 in.

Barnett's Liquid Iron Asphalt can be made either of natural or artificial asphalt, mixed with pulverised iron ore or sesquioxide of iron, and a small proportion of mineral tar. The materials are put into a caldron which is brought on to the works, and are made into a liquid state by heat, run over the surface, and smoothed in the same way as the other liquid asphalts mentioned; the thickness usually laid is about 2 in.

Tar Pavement.—Made by mixing with fine breese, or small coke, just enough of thick refuse coal-tar to make it somewhat sticky; put a thin layer on the smooth and hardened surface, on this spread a couple of inches of metal, or pebbles, or coarse gravel, then a thin layer of the prepared breese, covered lightly with fine gravel, and beat or press together. It is cheap, slightly elastic, and durable.

Concrete Pavements.—(*a*) The terrazo floors used in Italy at the present day are made in the following manner: 1st coat; a concrete, consisting of common lime $\frac{1}{4}$, sand and fine gravel $\frac{3}{4}$, laid 6 in. thick and well beaten with wooden rammers; after two days in that climate, it is sufficiently dry for the next coat. 2nd coat; a terrazo, consisting of pounded brick or tile $\frac{1}{4}$, common lime $\frac{1}{4}$, sand $\frac{1}{2}$, of the consistence of mortar, laid $1\frac{1}{4}$ in. thick, well beaten with a light flat rammer. After two or three days it is hard enough for the next coat. 3rd coat; a similar terrazo, but with the grit of broken stones instead of sand in it, laid on like a coat of plaster with a trowel. After this has been laid for one day, a layer of small hard broken stones is pressed into it; these stones should be of some substance that will take a polish, and be of uniform size (they are passed through a gravel screen), about that of a walnut: these being afterwards rubbed to a smooth even surface with some smooth hard stone, form a kind of mosaic-work. The stones are frequently selected by colour, and laid in the third coat to a rough pattern. They should be moistened with oil or water till hard set.

(*b*) Dig the earth out about 8 in., fill in with coarse gravel and stones, well rammed, and levelled about 5 in. Mix Portland cement to the consistence of cream, and pour over, spreading it with a stiff broom; when hard, mix finer gravel with cement and water, and fill up to within $\frac{3}{4}$ in. of the surface; when hard, mix clean sharp sand and Portland cement, half-and-half, with water to about the thickness of mortar, and finish, slightly rounding. It should not be walked on for a day or two. Cement must be Portland, and fresh.

Artificial Stone Flags.—Take one part of fresh and good quality Portland cement and three parts of small granite chippings (passed through a $\frac{3}{16}$ in. mesh sieve), these chippings having been previously washed and dried. Well mix the cement and chippings in a dry state. Now sprinkle water on carefully, using a fine rose to prevent the cement being washed through the chippings, and when thoroughly mixed (and before setting commences) fill the moulds, taking care to fill all angles and corners that the finished flags may have good sharp angles. The moulds, which are probably wooden frames, must be metal lined, and soft soap may be used to prevent sticking. When the flags are sufficiently hard, loosen the moulds and then immerse the flags in a tank (galvanised iron tank will do) of silicate of soda solution and allow them to remain two or three weeks. After this, remove the flags and stack them carefully in the open air to season; the seasoning should be allowed a

considerable time. To make silicate of soda, the silicate stone is first crushed in an edge-runner mill, and then put into steam-jacketed boilers with good caustic soda. Steam is then turned on and the heat causes the two ingredients to combine and form silicate of soda.

Granolithic.—This consists of one part Portland cement and three parts of granite chippings, red oxide being added to give the characteristic colour, if desired. The whole is first mixed dry, then wetted sparingly with a fine rose, well worked into a mass, and laid on a good foundation in the usual way. When set, the surface is polished with a rubber of York grit-stone, fixed in a handle with an iron shoe, water being freely used during the rubbing. The presence of the granite making the polishing possible, as cement only cannot be polished. Chippings of coloured marble can replace the granite and can be polished, but have not quite the good wearing qualities of granite.

Cement Slabs.—These are made in metal-lined moulds (as described with artificial stone slabs) with or without pressure. The cement is Portland, and should not only be good but well matured. Granite chippings are mixed with the cement about three to four parts to one part cement, the granite passing through a $\frac{1}{16}$ in. mesh sieve. After well mixing in a dry state, water is applied sparingly by a fine rose and the whole well mixed into a fairly stiff mass. The mixture is put into metal-lined moulds, the corners and angles being well filled and the whole rammed or beaten firm. When set hard, the slab is taken out and set in the open air to mature, if possible for three or four months. They are then in good condition for paving. A better slab is produced when pressure can be used. This necessitates stiff cast-iron moulds and a simple form of machine to effect the pressure with. By this means a good slab can be made with such a material as clinker to take the place of the granite and can be put to utilise some of the waste material from destructor furnaces. In laying these slabs, a bedding of sand or fine ash is put on the earth and a layer of lime mortar put on this. The slab is then laid and the joints between the slabs are grouted with thin mortar. This makes an excellent pavement.

Concrete.—It is sometimes contended that a concrete pavement or floor should consist of three layers, but there can be no doubt that the material of the two under layers can as well be mixed and laid as one. This would then consist of the roughest and a medium material, the latter filling the voids in the larger stuff. This layer is best allowed to set before the final coat which is made up of fine stuff. When this has been laid and ruled or levelled off, a short time should be allowed for it to commence setting, then the following finishing off process is done. Take a hand-float and beat the surface lightly until the "fat" appears or until it "creams," then trowel it off with light strokes and the finished surface will be smooth as if it was wholly cement. It is best to let the top coat get somewhat firm before the hand-float is used as described, for if this is done while the material is soft an uneven surface will result.

Coke Breeze.—This is more usually adopted for covered floors or walks. The coke should pass through a sieve of $\frac{3}{8}$ in. mesh, but not be so fine as to pass through a $\frac{1}{16}$ in. mesh; dust should not be used. Mix together $2\frac{1}{2}$ parts of coke, 2 parts clean sharp sand and 1 part Portland cement. Let the parts be measured, not guessed, and mixed in a dry state, then wetted sparingly with a rose. Mix into a stiff mass and use.

Wood Paving.—At the present time the various methods of wood paving have resolved themselves into one, viz. that of placing blocks, with the grain vertically, on a concrete foundation. The method is as follows: The macadamised road-bed is broken up and cleared to the required depth, the macadam,

when freed of dirt, going to make the concrete. The Portland cement should be of good make, the test strength being 350 lb. per sq. in. (tensile) at the end of 7 days, gradually becoming stronger over a period of 30 days. The concrete consists of 1 part (by measure) of cement, 2 parts clean sharp sand, 5 parts stone or broken brick to pass through a 2 in. mesh. This concrete is laid 5 in. thick and well rammed. A smooth surface is given this by a 1 in. layers of 1 part cement and 3 parts sand. The blocks vary in length from 7 in. to 9 in. and are 6 in. deep and 3 in. wide. When laid, all joints are filled in with liquid asphalt to ¾ in. height from the bottom, the remaining space being filled in with cement grouting. No joint should be wider than $\frac{5}{16}$ in. The blocks are laid in lines across the street, but are not taken nearer to the curb than 3 in., this space, on each side, being filled in with cement and sand (1 and 3), or

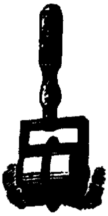


FIG. 98.

may be filled in with blocks afterwards. The concrete foundation should be laid six days before the blocks are put on it.

All Blocks must be Creosoted under Pressure before they are laid.—As a rule wood block is not used for roadways, when the inclination exceeds 1 in 30, owing to its becoming so slippery when wetted.

Cement.—Cement and sand (1 and 3) is now being largely used for footways in railway stations and similar places, this being laid on a concrete foundation where necessary. With the view to giving it the appearance of paving, lines are scored across it at regular intervals, these lines being formed with a tool like Fig. 98, just

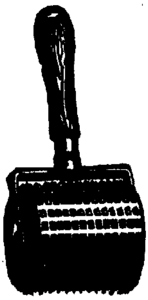


FIG. 99.

before the cement is firm. To prevent slipping on inclined places, the whole surface can be indented, this being effected with a tool as Fig. 99.

PEARL.

Mother-of-Pearl.—This is the inner coat of several kinds of oyster shells, some of which secrete this layer of sufficient thickness to render the shell an object of manufacture. The beautiful tints of the layer depend upon its structure, the surface being covered with a multitude of minute grooves, which decompose and reflect the light. The surface is a grooved structure like the delicate texture at the top of a child's finger. These ridges and grooves can sometimes be seen with the naked eye, but more often a magnifying glass is needed, as there may be 3000 to the inch. It is remarkable that if this surface is conveyed to certain other substances the iridescent hues will be communicated. Thus if an impression is taken of the surface of the shell in black wax, it will present the hues of the shell, which plainly indicates that the colouring is due to surface structure. A solution of gum arabic or isinglass, when allowed to indurate upon a surface of mother of-pearl, takes a very perfect impression of it, and exhibits all the colours that can be communicated in this way, in a very perfect manner, when seen either by reflection or transmission. If the isinglass solution is put between two finely polished specimens of shell, a film of artificial mother-of-pearl is obtained, which, when seen by a single light, will show the brightest tints.

The structure of the pearl shell admits of its being split into laminæ, and it can then be used for the handles of knives, for inlaying, or in the manufacture of buttons; but as splitting is liable to injure or spoil the shell, this method of dividing it is seldom resorted to. In manufacture the different parts are selected of a thickness as nearly as possible to suit the required purpose; excess of thickness is got rid of by means of saws, filing, or by grinding upon the common grindstone. In preparing the rough shell, if square or angular pieces are needed, they are cut with saws, as the circular saw or the ordinary back saw; in the one case, the shell is fed up as the saw divides it, and in the other the shell is held in a vice, and the saw operated by hand. If circular pieces of the shell are wanted, such as those for buttons, they are cut with an annular or crown saw, which is fixed upon a mandrel. It is necessary in sawing that water is plentifully supplied to the instrument or the heat generated by dividing the shell will heat the saw, and its temper will be destroyed. The pieces of shell are next ground flat upon a grindstone the edge of which is turned with a number of grooves or ridges, as being less liable to being clogged than the flat surface, and hence grind more quickly. It is necessary to supply water, or soap and water, to the stone, as it is then less liable to become clogged. The flat side of the stone, similarly prepared with ridges, may be used instead of the face, if it is desired to have the pieces of shell ground flat, and when of the requisite thinness they are ready for operation in the lathe, or for inlaying.

After the pieces of pearl shell are cut, ground, or turned to the proper form, they are finished with pumice and water; this may be done with pieces of the stone properly shaped, and rubbed over the work as it is held fast in some form of clamp, or held upon the work, as it is revolved in the lathe. This process may be followed by an application of ground pumice, which has been carefully sifted to extract all except the minutely powdered portion, and applied with a piece of cork or a cloth moistened with water. The polishing is accomplished with rotten-stone, moistened with dilute sulphuric acid, which may be applied upon a piece of cork or upon a piece of soft wood. In some turned works fine emery paper may be used, and followed with rotten-stone moistened with the acid or oil. The pearl handles used for razors or knives are first roughed out, then drilled where the

rivets are to be inserted, and lightly riveted together in pairs. They are ground to the proper size and thickness, then scraped and sand-buffed on the wheel with Trent sand and water; gloss-buffed with rotten-stone and oil (or with dry chalk), and finally with dry rotten-stone applied with a velvet covered pad or with the hand. The hand is commonly used for this last process. Sometimes it is advantageous to apply the polishing material to the surface of a wheel, and this wheel may be covered with cloth and moistened with water, which will cause enough of the powder to adhere. Separate wheels may be used for the pumice and rotten-stone. Sometimes dry powdered chalk or Spanish whiting is used in place of the rotten-stone.

One process of working pearl is by the aid of corrosive acids and the etching point. The shell is first divided as may be necessary, and the designs or patterns are drawn upon it with an opaque varnish; strong nitric acid is then brushed over the plates repeatedly, until the parts undefended by the varnish are sufficiently corroded or eaten away by the acid. The varnish now being washed off, the device, which the acid had not touched, is found to be nicely executed. If the design is to be after the manner of common etching on copper, the process upon the shell is precisely the same as that process upon metal. When a considerable number of pieces of thin shell are required to be of the same size and pattern, the requisite number of plates are cemented together with glue, and the device or figure is drawn upon the outer plate. They may then be held in a vice or clamp, and cut out as one plate with a fine saw, or wrought into the desired form with files; drilling tools may be employed to assist in the operation. To separate the pieces, the cemented shells are thrown into warm water, which softens the glue and separates the pieces.

Polishing Mother-of-Pearl.—(*a*) Take some finely powdered rotten-stone and add sufficient olive-oil to it to make a thick paste—like the thickest cream. Thin this with sulphuric acid to a thin cream, then apply it with a cork rubber which is covered with selvyt or similar velvet material. When the polish is obtained, wash the surface of the shell with plain water.

(*b*) In dealing with large numbers of shells a lathe, or grinding spindle, is provided with polishing bobs. These would be for the various stages of grinding level with emery, smoothing with rotten-stone, and polishing with whiting on buff leather. The polishing materials are moistened to a thin paste with vinegar or dilute sulphuric acid.

Inlaying with Mother-of-Pearl.—(*a*) Tortoiseshell is softened by soaking it in hot water—the design arranged, and placed between flat dies, under a heavy press, to remain till the shell is cold and dry. It is thus embedded in the shell. Those vivid colours on paper trays are fragments of the Aurora shell, pressed in the same way, while the paper is damp; when dry, the design is painted, varnished, baked, and polished.

(*b*) Thin scales of the shell are selected for their colour or shade, and cemented to the surface of the material. The rest of the surface is covered with successive coats of japan varnish, generally black, being subjected to a baking process after each application. When the varnish is as thick as the shell, it is polished, the gilding and painting are added, and a flowing coat of varnish is put over the whole.

(*c*) In preparing the shell for inlaying the pieces are cut with fine saws and are then ground on both sides until the required thickness—thinness really—is obtained. If very thin, any further cutting can be done with scissors, to form flowers, leaves, etc. If a number of pieces of one shape are desired, a foot-power die-press can be used. Another method of obtaining a number of pieces of similar shape, and which admits of any thickness of pearl being cut, is to glue several thicknesses of shell together, put the mass into a suitable vise or clamp,

then cut them out with a fine saw, finishing with drills or files as required. The pieces can then be separated by soaking in warm water.

Artificial Mother-of-Pearl Buttons.—White horn buttons may be made to imitate mother-of-pearl by being boiled in a saturated solution of sugar of lead, and then laid in very dilute hydrochloric acid. Combs, to which the boiling process is not applicable, as it distorts the teeth, may be treated by being kept over-night in a moderately concentrated cold solution of nitrate of lead, then laid for ½ hour in a bath containing 3 per cent. of nitric acid, finally being rinsed in water. The use of sugar of lead is however, prejudicial, and should be avoided.

Artificial Pearls.—It is supposed that the origin of the high quality artificial pearls first obtained from Paris was due to a French bead-maker observing that when a small fish called ablette or bleak was washed, a quantity of fine particles like silver was deposited in the water, and he collected some of these for the purpose of his trade—bead-making. On closer examination it was found that the material thus obtained resembled in a remarkable degree the lustre of pearl, and it afterwards became known as essence of pearl, or essence d'orient.

The first attempt at using this substance for producing artificial pearls was to cover solid beads of plaster externally, and although the effect was good and the "pearls" admired and bought, it was found that the external covering separated itself, wore off, and was generally unsatisfactory in the end. The next attempt was in the direction of hollow glass beads with the coating applied internally, and this method is the one practised at the present day.

The glass used is first prepared as tubes and its make or quality was originally called "girasol." It is slightly opalescent, with a peculiar bluish tinge. From this the glass-blower makes small globules, and a good worker can now produce several thousands per day. No great care is devoted to making them perfectly spherical, as the true pearl is not so. Another operator takes the globules, and, having a fairly hot solution of isinglass with the "pearl essence" in it, blows sufficient into each globule with a fine glass pipe. Each globule as done is placed on a table by the operator, who, by his foot, keeps the table shaking and so ensures the globules having the coat spread evenly in them. When dry, the globules or beads are filled with white wax or a composition of the substance of stiff wax. This gives the pearls solidity and the necessary weight, besides rendering them less fragile. They can then be bored and mounted on pins or threaded on silk. In the latter case, with best work, each bored hole is lined with paper, to prevent the silk thread adhering to the wax.

The "pearl essence" is now easily obtained, as the fish (about the size of a gudgeon) is a very common one. Originally it came from the river Seine but the demand soon became greater than this river could supply. A difficulty was then experienced in finding how the scales could be preserved to transport them distances, for it was found that if put in alcohol they lost their lustre. It was discovered, however, that the fishy particles could be preserved, without deterioration, in a solution of ammonia, and this enables the scales to be brought from distant places where the fish is abundant. About 4000 fish are required to produce a pound of scales and these yield about a ¼ lb. of essence. A full account of this industry appears in a French work entitled *L'Art d'imiter les Perles fines*. It is not a very modern book, but it remains a standard work on the subject.

PERFUMES, TOILET REQUISITES, ESSENCES, AND EXTRACTS.

(*See also* BITTERS, CONFECTIONERY, DISTILLING, ETC.)

Perfumes.—In the preparation of perfumes the alcohol or spirit used is rectified spirits 60° overproof, having about 96 per cent. alcohol. This alcohol is obtained from crude potato, maize or turnip spirit, this crude material being first diluted with water, filtered through wood charcoal, then rectified by distillation in a column still of the Coffey type. Several degrees of spirit are obtained, the best of which is that called "silent" spirit which has 96·4 per cent. pure alcohol and a trace of aldehyde. It contains no fusel oils. In addition to the manufacture of perfumes this silent spirit is made into drinking spirit by the addition of flavourings, and it is also used to strengthen wines and alcoholic beverages generally. It is important to note that this is not what is known as methylated spirit, nor can the latter ever be used for the same purposes. The first and chief process in making methylated spirit is certainly the same, as it is the first runnings of the Coffey still, of about 95 per cent. strength, but it is afterwards "denatured" by the addition of naphtha or wood spirit which makes it undrinkable and at the same time puts it outside the excise regulations as to drinkable spirit. There is no practical way of ridding methylated or denatured spirit of this additional denaturing material to make it suitable for perfumes. There are methods suited for the laboratory, but not for commercial purposes, and, as hinted, any such conversion may bring about difficulties with the excise department.

The following are recipes of most of the best known perfumes.

Ess. Bouquet.—10 oz. extract of rose, 10 oz. extract of cassia, 8 oz. extract of orris, 2 oz. extract of vanilla, ½ oz. essential oil of bergamot, ½ oz. essential oil of lemon, ½ oz. extract of civet, 40 drops otto of rose; mix.

Millefleurs.—10 oz. extract of rose, 10 oz. extract of cassia, 10 oz. extract of orange, 4 oz. extract of orris root, 4 oz. extract of vanilla, 1 oz. extract of musk, ½ oz. extract of civet, 4 drops essential oil of almonds, 8 drops oil of neroli, 20 drops oil of citron, 30 drops oil of bergamot, 6 drops oil of cloves, 6 drops oil of patchouli, 20 drops oil of rose geranium, 20 drops oil of lemon, 10 drops oil of lavender (English), 3 drops oil of citronella, 20 drops essence of otto of rose; mix.

Heliotrope.—(1) 6 oz. extract of vanilla, 10 oz. extract of rose, 5 oz. extract of orange, 5 oz. extract of cassia, 1 oz. extract of musk, 7 drops essential oil of almonds, 10 drops otto of rose; mix. (2) 1 part geranium oil, 4 parts best wintergreen oil, 3½ parts best almond oil, 15 parts lemon oil, 250 parts benzoin tincture, 500 parts rose tincture, 500 parts orris tincture, 1000 parts perfumers' alcohol, 250 parts distilled water.

New Mown Hay.—(1) 20 oz. extract of tonquin, 10 oz. extract of rose triple, 10 oz. extract of geranium, 10 oz. extract of jasmine, 10 oz. extract of orange, 12 oz. extract of rose, 2 oz. extract of storax; mix. (2) 2 parts patchouli oil, 15 parts bergamot oil, 5 parts geranium oil, 750 parts cumarin tincture, 750 parts orris tincture, 750 parts perfumers' alcohol, 250 parts distilled water.

Frangipanni.—10 oz. extract of rose, 10 oz. extract of cassia, 6 oz. extract of orange, 6 oz. extract of orris, 2½ oz. extract of tonquin, 2½ oz. extract of vanilla, ½ oz. extract of musk, ½ oz. extract of civet, 36 drops best oil of neroli, 40 drops best oil of geranium, 30 drops oil of bergamot, 5 drops oil of sandalwood, 20 drops otto of rose; mix.

Opoponax.—½ oz. pod musk, 2 oz. vanilla beans, 1 oz. tonquin beans, 5 pints rectified spirit of wine. Digest

28 days, and add: 20 oz. extract of orris, 10 oz. extract of rose, 10 oz. extract of jasmine, 10 oz. extract of cassia, 10 oz. extract of tuberose, ½ oz. oil of citron, ½ oz. oil of bergamot, 3 dr. otto of rose, 1 dr. oil of patchouli. Add last four after filtering.

Stephanotis.—20 oz. essence of white rose, 10 oz. extract of jasmine, ½ oz. extract of storax; mix.

Wallflowers. — 20 oz. extract of cassia, 20 oz. extract of orange, 20 oz. extract of rose, 10 oz. extract of orris, 1 oz. extract of vanilla, ½ oz. extract of storax, 20 drops essential oil of almonds, 40 drops otto of rose; mix.

Magnolia.—20 oz. extract of orange, 40 oz. extract of rose, 10 oz. extract of tuberose, 10 oz. extract of violet, 20 drops essential oil of almonds, 5 drops oil of citron, 5 drops otto of rose, ½ oz. extract of storax; mix.

Moss Rose.—10 oz. extract of rose, 5 oz. rose triple, 5 oz. extract of orange, 4 oz. extract of musk; mix.

Wild Rose.—8 oz. extract of cassia, 8 oz. extract of orange, 16 oz. extract of rose, 8 oz. rose triple, 20 drops essential oil of lemon, 20 drops oil of spearmint.

Rose.—15 parts bergamot oil, 40 parts geranium oil, 4500 parts perfumers' alcohol, 1000 parts distilled water.

White Rose.—5 oz. extract of rose, 4 oz. rose triple, 5 oz. extract of violet, 3½ oz. extract of jasmine, 1½ oz. essence of patchouli; mix.

Lilac Essence.—18 oz. extract of tuberose, 12 oz. extract of orange, 4 oz. extract of civet, 4 drops essential oil of almonds; mix.

Honeysuckle.—8 oz. extract of tuberose, 8 oz. extract of rose, 8 oz. extract of violet, 8 oz. extract of jasmine, 2 oz. extract of vanilla, 2 oz. extract of storax, 40 drops essential oil of almonds, 20 drops oil of neroli; mix.

May Blossom.—10 parts geranium oil, 40 parts bergamot oil, 50 parts linaloe oil, 1000 parts orris tincture, 500 parts distilled water, 3500 parts perfumers' alcohol.

Florida Water.—7 pints rectified spirit of wine, 2 pints rose water, 1½ oz. essential oil of lemon, 2 oz. English oil of lavender, 1 oz. oil of cloves, ½ oz. oil of lemongrass; mix.

Patchouli.—(1) 1 oz. oil of patchouli, ½ gal. perfumers' alcohol.

(2) 80 drops oil of patchouli, 10 drops otto of rose, 1 pint rectified spirit of wine; mix.

Eau de Cologne.—(1) 60 drops essential oil of bergamot, 60 drops essential oil of lemon, 60 drops oil of rosemary, 30 drops oil of lavender, 38 drops oil of neroli, 8 drops oil of citron, 16 oz. rectified spirit, 4 oz. orange flower water; mix oils with spirit of wine, gradually add orange flower water, then filter. (2) ½ oz. essential oil of lemon, ½ oz. essential oil of bergamot, ½ oz. essential oil of rosemary, 1 dr. oil of neroli, ½ dr. oil of thyme, 3 dr. essence of millefleurs, ½ oz. aromatic spirit of ammonia, 2½ oz. spirit of horse-radish, enough rectified spirit of wine to make 40 oz.; mix, let it stand in bulk for some time (the longer the more exquisite the blend), then filter. (3) 6½ parts oil of neroli, 14 parts oil of bergamot, 34 parts oil of lemon, 14 parts oil of rosemary, 20 parts petit-grain oil, 20 parts musk tincture, 6000 parts perfumers' alcohol; other ingredients in various makes of Eau de Cologne are lavender oil, Portugal sweet orange oil, thyme oil, lumetta oil, lemon rind oil, citron oil, German balm oil, cinnamon oil, pineapple oil, and sometimes an extremely small proportion of peppermint oil.

Lavender Water.—(1) 2½ oz. best foreign oil of lavender, 1 oz. extract of musk, 1 oz. essence of mareschale, ½ oz. essential oil of bergamot, 10 drops otto of rose, 6 oz. orange flower water, 32 oz. rectified spirit of wine; mix. (2) 16 fl. oz. oil of Mitcham lavender, 24 drops tincture of musk, 16 gal. of perfumers' alcohol, 2 gal. distilled water (warm); add the two first ingredients to the two latter, mix, and let stand until assimilated.

Sachet Powders. *Frangipanni Sachet.*—8 oz. powdered starch, 8 oz.

precipitated chalk, 1 oz. orris root, 60 drops oil of geranium, 2½ dr. extract of frangipanni; mix, and pass through a fine sieve.

Essence Bouquet Sachet.—4 oz. powdered starch, 4 oz. precipitated chalk, 1½ oz. orris root, 30 drops essential oil of bergamot, ½ oz. essence bouquet; mix and pass through a sieve.

Violet Sachet. — 8 oz. powdered starch, 4 oz. precipitated chalk, 6 oz. orris root, ½ oz. extract of wood-violet, 6 drops oil of neroli; mix well, and pass through a sieve.

Rose Sachet Powder.—1 lb. powdered starch, 1 lb. precipitated chalk, 8 oz. orris root, 10 drops otto of rose, 20 drops oil of rose geranium, 1 dr. extract of civet; mix, and pass through a sieve.

Jockey Club Sachet.—½ oz. powdered magnesia, 3 dr. essence of jockey club, 60 drops essence of musk, 4 oz. powdered orris root, 8 oz. powdered starch, 8 oz. precipitated chalk; mix, and pass through a sieve.

Perfumed Pomades. *White.*—8 oz. best white wax, 4 oz. tallow, 13 oz. lard; melt together by gentle heat, and on cooling, add 20 drops oil of bergamot, 10 drops oil of lemon, 6 drops oil of Peru balsam, 6 drops oil of cloves; stir well when perfumes are being added.

Black.—8 oz. best wax, 4 oz. tallow, 13 oz. lard; melt, and colour with bone black, adding perfumes as before.

Brown.—Use the same ingredients except bone black, for which substitute umber; same perfumes.

Red.—Melt wax, tallow, and lard, and use alkanet root for colouring; perfumes as before.

Toilet Articles. *Cologne Vinegar.*—1 oz. strong acetic acid, 1 pint Eau de Cologne; mix.

Rose Toilet Vinegar.—4 oz. rose petals (dried), 10 oz. rose triple, 5 oz. acetic acid, 85 oz. distilled water; put all together, and macerate in a closed vessel for 14 days, shaking frequently, then filter.

Brillantine.—4½ oz. best castor-oil, 4½ oz. absolute alcohol, 1½ oz. essence of jockey club, 12 drops otto of rose, 1 dr. tincture of saffron; mix, and after standing a few days, filter.

Bay Rum.—90 drops essential oil of bay-berries, 20 drops essential oil of pimento, ½ oz. acetic ether, ½ oz. powdered pumice-stone, 25 oz. rectified spirit of wine, 5 oz. distilled water, 10 oz. Jamaica rum; mix oils with spirit of wine, add rum, acetic ether, and distilled water, add pumice-stone last, and filter through paper. If preferred richer in odour, add 10 drops oil of absinthe.

Balm of Gilead.—4 oz. best gum benzoin, 16 oz. Canada balsam. Dissolve by heat, strain whilst hot, and to it add ½ oz. essential oil of rosemary, ½ oz. essential oil of lemon, ½ oz. oil of cassia; mix intimately.

Cherry Tooth Paste.—8 oz. clarified honey, 8 oz. precipitated chalk, 8 oz. powdered orris root, 1 oz. rose pink, 3 drops oil of cloves, 3 drops oil of nutmeg, 3 drops oil of rose geranium, enough simple syrup; rub the oils with the powder, and pass through a fine sieve, then mix into a paste with honey and enough syrup to make it soft.

Tooth Powder.—8 oz. best white soap, 8 oz. powdered French chalk, 8 oz. orris root, 4 oz. white sugar, 4 oz. rose water, 60 drops oil of cloves, ½ oz. oil of peppermint; cut up soap, and melt in water bath with rose water, rub oils with sugar, orris and chalk, then add it to above, stirring until well mixed.

Cold Cream.—½ oz. white wax, ¾ oz. spermaceti, 3 oz. oil of almonds, 4 oz. rose water; melt well, and stir until cold.

Superior Cold Cream.—10 oz. prepared lard, 4 oz. finest castor-oil, 2 oz. best English spermaceti; melt in a warm bath, and stir in gradually, after being mixed and dissolved add the following: ¾ oz. rose water, ¾ oz. elder flower water, 20 gr. powdered borax; add on cooling 20 drops essence of bergamot, 20 drops essence of otto of rose; and beat well until cold.

Honey and Glycerine Jelly.—70 gr.

Russian isinglass, 6 oz. rose water; dissolve in a water bath, and add 4½ oz. pure glycerine (fluid), 1½ oz. clarified honey, 6 drops otto of rose.

Rosemary Hair-Wash.—50 gr. salt of tartar, 2½ oz. rose triple, 9½ oz. rosemary water; make a lotion.

Violet Powder.—12 lb. powdered starch, 2 lb. orris root, ¼ oz. essential oil of lemon, ¼ oz. essential oil of bergamot, ½ oz. extract of civet, 1½ dr. oil of cloves; mix the powders intimately, then having mixed the perfumes, add them gradually. Pass twice through a sieve.

Rose Face-Powder.—7 lb. powdered starch, 30 gr. rose pink, 20 drops essential oil of bergamot, 10 drops otto of rose, 60 drops oil of rose geranium; mix well and pass through a sieve.

Essences.—The term essence implies a preparation of the essentially active portion of a substance, but it is widely and erroneously applied to a variety of decoctions, infusions, solutions, tinctures, and fluid extracts, as well as the alcoholic solutions of essential oils from plants. In preparing essences, the solid ingredients must be thoroughly bruised, powdered, or sliced, so as to expose them completely to the action of the spirit. When the active principle to be obtained is partly fixed and partly volatile, the most suitable process is simple digestion in alcohol, either weak or absolute, according to the solubility of the substance. The digestion or maceration should be continued for at least 10–14 days, and the materials should be repeatedly agitated, so as to ensure contact between all fragments. A more concentrated solution may be obtained by the process of displacement or percolation. When the object is to extract only an aromatic and volatile principle, a better method is to digest the materials in alcohol for a few days, and then subject the whole to distillation: the alcohol passes over in vapour, carrying with it the bulk of the volatile matters vaporisable at or below the distillation temperature of the alcohol employed. For all first-class articles, the alcohol used must be pure, and free from colour, odour, and flavour. The following are amongst the most important essences in use.

Aconite.—8 oz. dried powdered aconite herb, 16 oz. rectified spirit; macerate 4 days at 68° F. (20° C.), press, strain; the marc or residue is again macerated with a little spirit and pressed as before, so that the weight of the united tinctures may be double that of the herb.

Allspice.—1 fl. oz. essential oil of allspice (pimento), 1 pint strongest rectified spirit; agitate till perfectly mixed; next day decant the clear from the sediment.

Almonds.—(1) 1 fl. oz. essential oil of almonds, 1 pint spirit; proceed as Allspice.

(2) 1 fl. oz. essential oil, 7 fl. oz. spirit.

Ammoniacum.—(1) 1 lb. ammoniacum in tears, bruised in a cold mortar with ½ lb. coarse, well-washed, silicious sand or powdered glass, and ½ pint rectified spirit gradually added; trituration is continued till the whole is reduced to smooth paste, and it is then placed in a wide-mouthed bottle with ½ pint spirit of wine; digest for a week with frequent stirring, and after allowing to settle, decant the clear into another bottle for use.

(2) Reduce 1 lb. ammoniacum to a cream with ¾ pint boiling water; as soon as cool, put into a strong bottle, and cautiously add 1¼ pint rectified spirit of wine; cork tightly, and let macerate for a few days; put the bottle in a warm place for the sediment to go down, and filter off through flannel.

Anchovy.—(1) 1 lb. anchovies, boned, pulped in a stone mortar, and passed through a hair or wire sieve; boil the bones and the portion that will not go through the sieve in 1 pint water for 15 minutes, and strain; to the strained liquor add 2½ oz. each of salt and flour as well as the pulp, and simmer the whole for 3 or 4 minutes; remove from the fire, cool, and mix in ½ pint strong pickling vinegar; bottle, and secure

with wax, capsule, or bladder. Cochineal or annatto may be used for colouring.

Angelica.—1 oz. bruised angelica root, 8 oz. rectified spirit, 16 oz. water; digest, and distil over 6 oz.

Aniseed.—1 oz. oil of anise, 8 oz. rectified spirit.

Anodyne.—(1) 1 dr. powdered hard aqueous extract of opium, ½ dr. powdered cinnamon, 1 fl. oz. rectified spirit; digest a week.

(2) 5 dr. recent extract of henbane, 2 fl. oz. rectified spirit; digest a week.

Aromatic.—1 dr. hay saffron, 6 fl. dr. rectified spirit; digest together, filter; to filtrate add 1 dr. oil of cinnamon, 1 dr. powdered white sugar, 2 fl. dr. rectified ether, ½ dr. oil of nutmeg, ½ dr. essence of ginger; after shaking and a few days' repose, decant the clear.

Bark.—(1) 4 dr. resinous extract of yellow bark, 1½ fl. oz. rectified spirit, ½ fl. oz. tincture of orange-peel, 1 fl. dr. acetic acid; digest a week.

(2) ½ dr. quinine disulphate, 2 dr. resinous extract of bark, 2 fl. oz. rectified spirit; digest a week.

Beef.—(1) 1 lb. lean beef chopped small, ½ pint water; put into large bottle and shake violently ½ hour; strain the liquid into a jug; boil the solid residue in 1 pint water for 20 minutes; strain, and add the liquid to the previous cold infusion; evaporate to consistence of thin syrup, add salt and spice to taste, and while boiling hot pour into cans or (previously heated) bottles, hermetically seal, and store in a cold place.

Camphor.—(1) 4½ oz. clean camphor dissolved in 1 gal. rectified spirit.

(2) 13 fl. dr. tincture of camphor, ½ fl. dr. tincture of myrrh, 18½ fl. dr. rectified spirit.

(3) 1 dr. camphor dissolved in 2½ oz. rectified spirit; add ½ oz. water.

(4) 1 dr. powdered camphor dissolved in 12 fl. oz. water saturated with carbonic acid gas.

Caraway.—As Allspice.

Cardamom.—5½ lb. lesser cardamom seeds ground in a pepper-mill, 1 gal. rectified spirit of wine; digest for a fortnight, press, filter.

Cassia.—As Allspice.

Cayenne.—(1) 3 lb. recently-dried capsicum pods, 1 gal. rectified spirit; digest 14 days, press, filter.

(2) 1 oz. cayenne pepper, 1 pint brandy; digest, press, filter.

Celery.—4½ oz. bruised celery seed, 1 pint proof spirit; digest 14 days, strain.

Chamomile.—(1) As Allspice.

(2) 1 lb. sliced or bruised gentian root, ½ lb. dried orange peel, 1 gal. proof spirit, 3½ fl. oz. essential oil of chamomile; macerate a week.

(3) ½ lb. quassia wood may replace the gentian and orange peel.

Cinnamon.—(1) As Allspice.

(2) 5 oz. cinnamon, ¾ pint rectified spirit, ¼ pint water; digest a week, strain.

Cloves.—(1) As Allspice.

(2) 3½ oz. bruised cloves, ¾ pint proof spirit, ¼ pint water; digest a week, strain.

Cochineal.—2 oz. cochineal, 2 oz. subcarbonate of potash, 2 oz. potash alum, 2 oz. cream of tartar, 20 oz. distilled water. Boil the cochineal and potash together for about 10 minutes, then stir in gradually the cream of tartar and alum; strain through muslin, and afterwards filter through paper. To the filtrate add ½ lb. loaf sugar and dissolve with gentle heat.

Coffee.—4 oz. coffee, 2 oz. chicory, 1 oz. caramel (burnt sugar); prepared by percolation of the coffee with boiling water gently and quickly evaporated to ½ or ¼ its bulk, adding a thick aqueous extract of the chicory and syrup of burnt sugar so as to give the whole a treacly consistence.

Coltsfoot.—(1) 1 oz. tolu balsam, 3 oz. rectified spirit, 3 oz. compound tincture of benzoin; dissolve; in a few days decant the clear.

(2) 1 oz. tolu balsam, 1 oz. compound tincture of benzoin, 2 oz. rectified spirit.

Dill.—(1) As Allspice.

(2) ½ oz. oil of dill ½ oz. extract of

dill, 1 oz. salt of tartar, 1 pint rectified spirit; digest, strain.

Fennel.—As Allspice.

Ginger.—(1) 5 oz. bruised unbleached Jamaica ginger, 1 pint rectified spirit; digest a fortnight, press, filter.

(2) As (1) with addition of very little essence of cayenne.

(3) 12 lb. best unbleached Jamaica ginger in coarse powder digested in 2½ gal. rectified spirit for 14 days; the expressed and strained tincture is reduced by distillation in a steam or water bath to 1 gal., cooled, transferred rapidly to stoppered bottles, and filtered.

(4) Equal parts best unbleached Jamaica ginger in coarse powder, and silicious sand, sprinkled with enough rectified spirit of wine to perfectly moisten; after 24 hours the mass is placed in a percolator, and after returning the first runnings 2 or 3 times, the receiver is changed, and more rectified spirit is poured on gradually and at intervals as required, until as much essence is obtained as there has been ginger employed.

(5) Causes no turbidity with water or syrup. 1 lb. finest Jamaica ginger in powder, macerated in 8 oz. rectified spirit for several hours; add more spirit, and percolate to 16 oz.; add 2 oz. heavy carbonate of magnesia, agitate, and add 24 oz. water; shake well, and filter. If the filtrate is turbid, shake up with more magnesia, and filter again. It becomes turbid again after a few days' rest, but on filtering continues clear. (Thresh.)

(6) As (5) entails a loss of active principle in the magnesia precipitate. Thresh gives the following modification: take 1 pint strong tincture (1 to 1) finest Jamaica ginger; add in small portions at a time finely-powdered slaked lime, shaking vigorously after each addition until nothing further is precipitated; throw the whole on a filter, and pass proof spirit through the residue until the product measures 2 pints. Add dilute sulphuric acid drop by drop until the rich yellow colour of the tincture suddenly disappears; let stand 24 hours, filter, dilute with water to 4 pints, shake with a little powdered pumice or silica, and filter at 32° F. (0° C.) if possible.

Headache.—(1) 1 dr. oil of lavender (Mitcham), 1 oz. camphor, 4 oz. liquor ammoniæ, 1 pint rectified spirit; dissolve.

(2) 2 lb. spirit of camphor, 4 oz. strong water of ammonia, ½ oz. essence of lemon.

Hop.—26½ oz. new hops (rubbed small), 1 qt. proof spirit; digest 24 hours, then distil 1 pint over (quickly), and set the distillate aside in a corked bottle; to the residue add 1 pint water, boil 15 minutes, cool, express the liquor, strain, and evaporate as quickly as possible to dryness by a water bath; powder the residue, and add to the distilled spirit; digest a week, and filter.

Lemon.—(1) 1 fl. oz. fresh oil of lemons, 8 fl. oz. alcohol (strongest flavourless rectified), ½ oz. exterior yellow rind of lemons (fresh); digest 48 hours, and filter.

(2) ½ lb. yellow peel of fresh lemons, 1 pint spirit of wine; digest for a week, press, and filter.

(3) 1 lb. yellow peel of fresh lemons, ½ gal. boiling water; infuse 1 hour, express the liquor, boil down to ½ pint, cool, and add ½ oz. oil of lemon dissolved in 1½ pint spirit of wine; mix, and filter.

(4) Soluble essence: 1½ oz. essence of lemon, 6 oz. rectified spirit of wine, 3 oz. pure glycerine, 4 oz. pure phosphate calcium; mix essence of lemon, spirit of wine, glycerine, and 8 oz. of distilled water, agitate briskly in a quart bottle for 10 minutes, and now introduce phosphate of calcium, and again shake. Put in a filter and let it pass through twice. Now digest in filtrate for 2 or 3 days, 1½ oz. fresh lemon peel, and again filter.

Lovage.—2 oz. lovage root, 1 oz lovage seeds, 10 oz. rectified spirit, digest a week, and filter.

Nutmeg.—As Allspice.

Orange.—(1) As lemon. (2) 4 oz. fresh yellow rind of orange, ½ pint rectified spirit, ½ pint water; digest for a week, press, filter; add 1 qt. sherry.

(3) In the 'Journal of Pharmacy,' Mr. M. Bond describes an improved method of preparing this extract as follows: sweet orange peel, in moderately fine powder, 16 oz.; glycerine, 3 fl. oz.; alcohol, water. Having mixed 14 fl. oz. alcohol with 2 fl. oz. glycerine, the peel is moistened in a Wedgwood mortar with 12 fl. oz. of this mixture. After standing 12 hours percolation is conducted in the usual manner. The percolation is finished with a mixture of 2 parts alcohol and 1 part water. Reserving the first 14 fl. oz., add 1 fl. oz. of glycerine to the remainder, evaporate to 2½ fl. oz., which mix with the reserved portion. The author describes this preparation as possessing all the aroma of the orange peel. 1 fl. oz. mixed with 15 fl. oz. of syrup gives an excellent syrup aurant. quite clear. By adding to a pint of simple syrup 4 fl. dr. of the extract, and a few drops of solution of citric acid, a most delicately flavoured and unfermentable syrup for mineral waters is produced.

Peach.—Oil of almonds, 3 dr.; pineapple oil, 3 dr.; tartaric acid, 3 dr.; alcohol, 80°, 1½ pint.

Pear, jargonelle. — The essential flavouring ingredient in this fruit is amyl acetate.

Pennyroyal.—As Peppermint.

Peppermint.—(1) 1 oz. oil of peppermint, 4 oz. rectified spirit; mix.

(2) To (1) add ½ oz. herb of peppermint, or parsley or spinach leaves (preferably one of the first two), digest for a week, or until sufficiently coloured; 10 or 12 gr. sap green rubbed up with a teaspoonful of hot water, is also used for colouring.

Pineapple.—(1) Pineapple essence, 2 oz.; citric acid, 1 oz.; alcohol, 80°, 2 pints.

(2) The essential flavouring ingredient in this fruit is ethyl butyrate.

Quassia.—(1) Digest 1½ oz. sliced quassia in 1 pint of proof spirit for 10 days, and filter.

(2) Equal parts powdered quassia (sprinkled with a little rum) and "foot" sugar, reduced to the consistence of a semifluid extract by the addition of a few spoonfuls of water.

(3) 1 oz. powdered quassia, 2 oz. burnt sugar colouring, well stirred together. Used as fraudulent substitutes for hops.

Quince.—The essential flavouring ingredient in this fruit is ethyl pelargonate.

Quinine. — 1½ oz. disulphate of quinine, ½ pint rectified spirit; digest with warmth, gradually dropping in a little dilute sulphuric acid (avoiding excess), and constantly agitating until the whole is dissolved. Every fl. dr. contains 8 gr. disulphate of quinine, or about 10 gr. of the neutral sulphate. If more sulphuric acid is added than suffices to dissolve the salt (i.e. convert it into a neutral sulphate), the solution is apt to deposit part of it on keeping, owing to the gradual formation of ether by the action of the excess acid on the alcohol.

Raspberry.—Raspberry essence, 3 dr.; tincture of orris, ½ oz.; citric acid, ½ oz.; liquid carmine, 15 drops; extract rose, ½ oz.; alcohol, 80°, ½ pint.

Rennet.—For the preparation of concentrated solutions, only dried calves' stomachs are suitable, and those which have been blown out with air and dried as quickly as possible are best. The small stomachs of the youngest animals are richest in ferment. Fresh stomachs are useless for preparing a concentrated essence, as they yield a thick jelly which, by filtering, gives only a small quantity of liquid. Concentrated extract prepared from stomachs under 14 days is light yellow in colour, whilst that prepared after 6 to 8 months' storage of the stomachs is dark brown. This results from slight decay of the stomach, and as the colour does not affect the usefulness of the product, it is advisable to use stomachs which have

been stored for at least 3 months. The portion of the stomach without folds, the *portio pylorica*, is cut away, as it is poor in ferment.

Acid liquids are usually employed for extracting, as they seem to produce richer solutions, but this is only because they act more quickly at first than water alone. Hydrochloric acid, containing 0·1 and 0·2 per cent. of acid, in 2 days gave extracts twice as rich in ferment as an aqueous one; but after 8 days all 3 solutions were equally strong. A little thymol was added to prevent decomposition during the experiment. When the temperature is raised to 86°-95° F. (30°-35° C.), water acts more rapidly than the acid, and the solution is richer than that produced by acid at the ordinary temperature.

Attempts were made to produce concentrated solutions by means of dilute acids, but without success. A 0·3 per cent. solution of salicylic acid gave a liquid which was quite fresh after 12 months, but after only 2 months its activity had fallen off to the extent of one-half.

A series of experiments made with solutions of common salt containing from 2 to 26 per cent. shows that solutions containing 3 to 6 per cent. of salt yield the liquids richest in ferment, and capable of the highest degree of concentration.

This property of dilute salt solutions depends on the fact, made known by Graham, that common salt is a very easily diffusible substance. Organic acids in combination with common salt are no better extraction agents than the salt alone; 5 per cent. solutions of sodium or potassium sulphate are less efficacious than the same strength of salt solution. Potassium chloride behaves in much the same manner as common salt; an excess of the potassium chlorate, however, neither acts as efficiently as a precipitating agent nor as a preventive of decomposition.

60 to 80 grm. of calf's stomach, steeped for 5 days in 1 litre of a 5 per cent. solution of common salt at ordinary temperatures, yield a solution of which 1 vol. will coagulate 10,000 vol. of new milk at a temperature of 95°F. (35°C.) in 40 minutes. If the filtered solution is treated with 60 to 90 grm. more of stomach, a dilution of double strength is obtained; another repetition gives a solution 3 times the strength of the original.

To prevent decomposition, about 0·3 per cent. of thymol may be added to the concentrated rennet extract solution. Possibly a slight taste due to this may be detected in the finest cheese, but for the same reason oil of cloves is much more objectionable. Boric acid is on all accounts the best antiseptic to employ, and solutions to which it has been added may be kept in covered vessels for months. (*See* PRESERVING.)

All extract solutions lose strength on keeping; during the first 2 months the solution may become 30 per cent. weaker, then the strength remains nearly constant for 8 months in the case of a solution of 1 : 18,000. Alcohol is almost as good an antiseptic as boric acid, if the solution be preserved in well-stoppered flasks.

Detailed experiments show that the time required to coagulate milk is inversely proportional to the strength of the extract solution. From this the strength of a solution can be determined by adding 1 c.c. to 1 litre of milk at 95° F. (35° C.), and noting the time required to coagulate the milk: this time multiplied by 10 gives the time for the proportion 1 : 10,000. (H. Sohxlet.)

Rhubarb.—5 oz. rhubarb powder, 5 oz. silicious sand, 1 pint proof spirit; extract by displacement.

Royale.—40 gr. ambergris, 20 gr. musk, 10 gr. civet, 10 gr. carbonate of potash, 6 drops oil of cinnamon, 4 drops oil of rhodium, 4 drops otto of roses, ½ pint rectified spirit of wine; macerate 10 days or longer.

Sarsaparilla.—(1) 2¼ lb. sarsaparilla root (best red Jamaica) carefully decorticated, the bark reduced to coarse powder. Digest for 7 to 10 days in ¾

pint sherry and ½ pint rectified spirit, with frequent agitation; the essence is expressed, and in a week the clear portion is decanted from the sediment.

(2) 10 oz. bruised sarsaparilla, 6 pints distilled water; macerate at a temperature of 120° F. (49° C.) for 6 hours, and strain; repeat with the same quantity of fresh water; mix the liquors, and evaporate in china vessels at 160° F. (71° C.).

(3) 2¾ lb. bark separated from sarsaparilla root, exhausted with water as (2); the liquid is evaporated as quickly as possible in a water bath to 16 fl. oz. and when cold mixed with 4 fl. oz. rectified spirit.

(4) 8 oz. bruised sarsaparilla, q.s. hot water; exhaust the root by successive macerations, unite the liquors, and evaporate to 10 fl. oz.; strain, and add when cold 4 fl. dr. each alcohol (0·842) and tinctures of guaiacum and mezereon, 1 fl. oz. white wine, 12 drops oil of sassafras, 2 dr. extract of liquorice; agitate, and after repose decant as before.

Savoury Spices.—(1) 4 oz. black pepper, 3 dr. powdered turmeric, 1½ dr. coriander seeds (all ground), 1½ fl. dr. oil of pimento, ½ dr. each oils of nutmeg, cloves, cassia, and caraway, 1 pint rectified spirit; digest with agitation for a fortnight.

(2) 3 oz. black pepper, 1½ oz. allspice, ½ oz. each nutmegs and burnt sugar, 1 dr. each cloves, cassia, coriander, and caraway seeds (all bruised or ground), 1 pint rectified spirit; digest with agitation for 14 days, press, and filter.

Soap.—4 oz. Castile soap (in shavings), 1 pint proof spirit; dissolve, and add a little perfume.

Soup Herbs.—1 oz. each lemon thyme, winter savory, sweet marjoram and sweet basil, ½ oz. each eschalots and grated lemon-peel, ½ oz. bruised celery seed, 1 pint proof spirit or brandy; digest for 10 to 14 days.

Spruce.—A decoction of the young tops of the black spruce fir, evaporated to the consistence of a thick syrup. Used to make spruce beer, etc.

Vanilla.—(1) 2 oz. vanilla beans (cut small), 1 pint rectified spirit of wine; macerate one month, and filter.

(2) This flavour is familiar as a result of its presence in chocolate, ices and other confections. The actual source is the pod or fruit of the vanilla plant. Close inspection of these shows them to be covered with a white efflorescence; this consists of the essential principle of vanilla, which has exuded and crystallised. To this body the name of vanillin has been given. Vanillin constitutes about 2 per cent. of the pod, and like many other flavouring and odoriferous substances is an aldehyde in composition. To obtain the flavour of vanilla in the most thorough and efficient manner there is probably no simpler method than to powder the pods themselves with sugar as a diluent, say 1 part of vanilla to 9 parts of sugar. The objection to this is that in light-coloured cakes and ices the appearance of what look not unlike particles of snuff scattered throughout the substance is unsightly. To obviate this, a tincture or essence of vanilla may be prepared by macerating the vanilla in alcohol and filtering off from the insoluble matter. The solution thus obtained yields all the flavouring bodies of the pods without the presence of the objectionable solid portion.

Vanillin is one of those substances which has been artificially prepared, the process usually adopted being that of subjecting eugenol, the essential constituent of oil of cloves, to a process of oxidation. When thus prepared and thoroughly purified, vanillin consists of a white crystalline matter of an intense vanilla odour. It is important that the vanillin should be thoroughly freed from the oil of cloves from which manufactured, or else the substance is liable to have itself a distinct odour and taste of cloves. Vanillin is liable to adulteration with various harmless but valueless substances, the presence or absence of which can be determined by analysis.

The manufacturers point out that a mixture of 2½ per cent. of vanillin in sugar is equivalent in strength to the vanilla pod itself. As the equivalent of the confectioner's "vanilla sugar," they recommend that 2½ per cent. vanillin sugar should be taken in the same quantity as would be taken of vanilla itself. Vanillin forms a very useful substitute for vanilla, and from its greater cheapness is somewhat extensively used. It is doubtful, however, whether for the most delicate flavouring purposes it can be considered a *complete* substitute for true vanilla. While undoubtedly, vanillin is the chief and predominant flavouring ingredient of vanilla, yet it is probable that there are traces of other flavouring matters present, and the flavour of the pod is therefore that of vanillin, *plus* such additional flavours as are given by these other bodies, which are absent in artificial or synthetic vanillin.

Reverting a moment to the essence of vanilla, while the best is prepared from fresh pods, inferior qualities consist of tinctures made from the almost exhausted residue, which are subsequently fortified by the addition of artificial vanillin.

Water Fennel.—1 oz. water fennel seed (fine-leaved water hemlock, bruised), 4 fl. oz. proof spirit; digest.

Westphalian.—(1) 3 dr. tar, 2 oz. sugar colouring, 1 pint hot crude pyroligneous acid; agitate constantly for 1 hour, and after repose decant the clear portion.

(2) ½ oz. Barbadoes tar, 1 oz. burnt sugar, 1 oz. common salt, ½ pint strong pickling vinegar, ½ pint port or elder wine; digest as before. Used to impart a smoky flavour to meat, fish, etc., by brushing over, or adding a little to the brine in which they are pickled.

Wormwood.—(1) 4 oz. extract of wormwood, 1 oz. oil of wormwood, 1 pint rectified spirit; digest a week, and filter.

(2) 1 pint tincture of wormwood, 5 dr. salt of wormwood, 1 dr. extract of wormwood; digest as before.

Fruit Essences, Artificial.—Kletzinsky published years ago formulas for 15 fruit essences, which were republished by several journals. Some of these formulas were again produced in the 'Confectioner's Journal' without any alterations, except that in the essence of apple the quantity of oxalic acid was reduced from 1 to ½ part, and glycerine from 4 to 2 parts; in essence of raspberry the succinic acid was entirely omitted, and essence of peach was directed to be made of 2 oz. oil of bitter almonds, 1 oz. acetic ether, and 2 pints alcohol; but the latter product has evidently the flavour of peach kernels accompanied by a slight fruit odour. The flavour of peach fruit may be imitated by using 5 parts each acetic-butyric and amyl-acetic ethers, ½ (or less) of methyl-salicylic ether (oil of wintergreen), 2 or 3 parts oil of bitter almonds, and 80 or 100 of alcohol.

Kletzinsky's formulas for the extracts of strawberry and raspberry are much improved by adding 10 to 20 per cent. of tincture of orris root. If desired, the rather acrid taste of this tincture may be removed by precipitating the resin, and if solution of lead acetate is used for this purpose, the filtrate should be carefully freed from any excess of lead by sulphuretted hydrogen, or by agitation with solution of sodium sulphate, which salt, being insoluble in the alcoholic liquid, will not impart its peculiar saline taste. The tincture of orris may probably be conveniently replaced by an alcoholic solution of the oil of orris, which has been an article of commerce for some years past.

Since several very important errors had crept into the formulas of Kletzinsky as first published, some of which are, however, readily corrected, it has been thought best to republish all the formulas from Wittstein's 'Vierteljahresschrift,' xvi. p. 268. These formulas are given in parts by measure for 100 parts alcohol, and whenever acids are used, they are to be previously dissolved in alcohol.

Apple.—Aldehyde, 2 parts; chloroform, acetic ether, nitrous ether, and oxalic acid, each 1; glycerine, 4; amyl-valerianic ether, 10.

Apricot.—Butyric ether, 10; valerianic ether, 5; glycerine, 4; amylic alcohol, 2; amyl-butyric ether, chloroform, œnanthic ether, and tartaric acid, each 1.

Banana.—Consists usually of butyric ether and amyl-acetic ether, equal parts, dissolved in about 5 parts alcohol.

Blackberry.—Tincture of orris root (1 to 8), 1 pint; acetic ether, 30 drops; butyric ether, 60 drops.

Black Cherry.—Benzoic ether, 5; acetic ether, 10; oil of persico (peach kernels) and benzoic acid, each 2; oxalic acid, 1.

Cherry.—Benzoic ether, acetic ether, each 5; glycerine, 3; œnanthic ether and benzoic acid, each 1.

Currant.—Acetic ether, tartaric acid, each 5; benzoic acid, succinic acid, benzoic ether, aldehyde, and œnanthic acid, each 1.

Grape.—Œnanthic ether, glycerine, each 10; tartaric acid, 5; succinic acid, 3; aldehyde, chloroform, and formic ether, each 2, and methyl-salicylic ether, 1.

Lemon.—Oil of lemon, acetic ether, and tartaric acid, each 10; glycerine, 5; aldehyde, 2; chloroform, nitrous ether, and succinic ether, each 1.

Melon.—Sebacylic ether, 10; valerianic ether, 5; glycerine, 3; butyric ether, 4; aldehyde, 2; formic ether, 1.

Nectarine.—Extract of vanilla, 2 parts; essence of lemon, 2; essence of pineapple, 1.

Orange.—Oil of orange and glycerine, each 10; aldehyde and chloroform, each 2; acetic ether, 5; benzoic ether, formic ether, butyric ether, amyl-acetic ether, methyl-salicylic ether, and tartaric acid, each 1.

Peach.—Formic ether, valerianic ether, butyric ether, acetic ether, glycerine, and oil of persico, each 5; aldehyde and amylic alcohol each 2; sebacylic ether, 1.

Pear.—Acetic ether, 5; amyl-acetic ether and glycerine, each 2.

Pineapple.—Amyl-butyric ether, 10; butyric ether, 5; glycerine, 3; aldehyde and chloroform, each 1.

Plum.—Glycerine, 8; acetic ether and aldehyde, each 5; oil of persico, 4; butyric ether, 2; formic ether, 1.

Raspberry.—Acetic ether and tartaric acid, each 5; glycerine, 4; aldehyde, formic ether, benzoic ether, butyric ether, amyl-butyric ether, acetic ether, œnanthic ether, methyl-salicylic ether, nitrous ether, sebacylic ether, and succinic acid, each 1.

Strawberry.—Butyric ether and acetic ether, each 5; amyl-acetic ether, 3; amyl-butyric ether, and glycerine, each 2; formic ether, nitrous ether, and methyl-salicylic ether, each 1.

The different manufacturers of artificial fruit essences doubtless prepare them by formulas of their own, and this explains the difference in the flavour, which is particularly noticeable on largely diluting them with water. If the essences have been prepared with a dilute alcohol, their odour is more prominent, and they are apparently stronger; but on mixing a small quantity with a large amount of water in given proportions, the true flavouring strength may be better discerned.

The red colour of strawberry and raspberry essences is produced by aniline red (fuchsine), the bluish tint of which is conveniently neutralized by a little caramel. If caramel alone is used for colouring essence, a yellow or brown colour is obtained, according to the quantity used. (Maisch, 'Amer. Jl. Pharm.')

Extracts are preparations of vegetable juices obtained by expression, decoction, or infusion, and evaporated down to a solid or semi-solid consistence. They are distinguished, according to their solvents, as aqueous or watery, alcoholic, spirituous (proof or u.p. spirit), acetic (dilute acidulated water), and ethereal. Fluid extracts are those evaporated only to a thin

syrupy consistence, and mixed with $\frac{1}{8}$ to $\frac{1}{10}$ volume of rectified spirit. The terms simple and compound distinguish whether one or more substance has been extracted.

The process of preparing pharmaceutical extracts divides itself into two operations—obtaining a solution of principle required, and evaporating that solution to a dense consistence. The first step is to reduce the solid substance to a state that will admit of its complete exhaustion by the solvent. This exhaustion is effected by digestion, displacement, decoction, or expression, and the resulting solution is carefully filtered.

The elimination of the excess water in order to bring the solution to the desired consistence, is usually performed by evaporation. This may be conducted in an open shallow pan, in a water-bath, in a double-jacketed pan heated by steam, or in a vacuum-pan. The first method is objectionable from the danger of incineration; the second is good if $\frac{1}{5}$ part of salt be added to the water in the bath, raising its boiling-point nearly 7° F., and thus ensuring an internal temperature of fully 212° F. (100° C.). Steam-jacketed pans are commonly used on the large scale; extracts prepared *in vacuo* are found to be much superior to the ordinary articles.

For several reasons, all those processes would seem to be inferior to that introduced by Prof. Herrara, whose observations satisfied him that, when the water partially congeals, the dissolved principles remain in solution in the mother liquors, and that 2 or 3 congelations are generally sufficient for obtaining the solutions concentrated enough to finish the extract by exposure upon plates to the heat of the sun, or in a drying closet heated to 86° F. (30° C.). Extracts prepared by this method accurately represent the properties of the plants, and those principles which are changed or volatilised by the influence of heat remain unaffected. The apparatus required is very simple, being mainly a modification of the *sorbetière*, or ice-cream freezer. The freezing mixture may be ice and salt, or ice and calcium chloride. As the congelation progresses, the ice-cake is removed broken up and pressed, to separate the mother-liquor as completely as possible, which is finished by evaporation in shallow dishes.

Extracts should be preserved out of contact with the air as soon as they are prepared. When in pots the inner surface of the bladder used to tie them down should be moistened with a few drops of oil of cloves or creosote. Hard extracts may be kept in gut-bladders, covered over in stone pots. The essential qualities of a good extract are: (1) Freedom from grit and complete solubility in 30 parts of the solvent used in its preparation, forming an almost clear solution; (2) proper consistence and uniform colour and texture. Extracts should be rejected as worthless when over 6 months old. The following are some of the chief kinds.

Aconite.—(1) Bruise 112 lb. fresh leaves and flowering tops, press out the juice, heat it gradually to 130° F. ($54\frac{4}{9}$° C.), and separate the green matter by a calico filter. Heat the strained liquor to 200° F. ($93\frac{1}{3}$° C.) to coagulate albumen, and again filter. Evaporate the filtrate by a water bath to the consistence of a thin syrup; add the green colouring matter previously separated, and, stirring the whole together assiduously, evaporate at a temperature not exceeding 140° F. (60° C.) to a pill consistence.

(2) Beat the fresh leaves of aconite to a pulp, and express the juice; subject the residue to percolation with rectified spirit until the latter passes through without being materially coloured; unite the expressed juice and the percolated tincture, filter, distil off the spirit, and evaporate in a vapour or a water bath to a proper consistence.

(3) The juice is expressed from the fresh herb, which is then sprinkled with about $\frac{1}{6}$ of its weight of water,

and again pressed; the mixed and strained liquid is evaporated in a vapour-bath at 122° to 140° F. (50°-60° C.). to about ½; to this as soon as cold, an equal weight of spirit (sp. gr. 0·900) is added; and after frequent agitation for 24 hours, the whole is filtered, with pressure; the marc is treated with fresh spirit (equal to about ¼ that first used) and again pressed; the mixed liquors are filtered and evaporated, as before, to the proper consistence.

(4) Ammoniated.—1 dr. extract of aconite, 10 or 12 drops strongest liquor of ammonia; mix.

(5) Dried.—The expressed juice, strained through a sieve or coarse linen, is at once exposed in earthen dishes, in layers of about 2 lines deep, in a stove or current of dry air, to a temperature ranging between 95° and 104° F. (35°-40° C.), until reduced to dryness. The dried extract is packed in bottles.

(6) Saccharated.—4 oz. extract of aconite, 1 oz. sugar of milk in powder; mix; dry the mass in a warm place, adding sugar of milk q.s. to make the whole equal in weight that of the extract used (4 oz.).

Aloes.—(1) 1 lb. Barbadoes aloes in small pieces, treated with 1 gal. boiling water for 12 hours, and the clear liquid evaporated.

(2) 1 lb. Socotrine aloes treated with 1 gal. boiling water for 12 hours, and the clear liquid evaporated to dryness.

(3) 4 oz. aloes (hepatic), 1 qt. water; boil till dissolved; when cold, decant the clear liquid, and evaporate as before.

(4) Macerate powdered aloes in cold water for 48 hours, with frequent agitation, and then evaporate in a water bath at a temperature not exceeding 150° to 165° F. (65½° to 74° C.), until a pilular consistence is obtained.

Belladonna.—(1) Bruise 112 lb. fresh leaves and tender branches in a stone mortar, and press out the juice; proceed as in Aconite (1).

(2) Express the juice from the bruised fresh plant, sprinkle the marc with water, and again apply pressure; mix the expressed liquids, filter and evaporate the filtered liquor in a vapour bath to the consistence of an extract.

Cherry, Wild.—Fluid. 16 oz. wild cherry in fine powder, 4 oz. glycerine, 8 oz. water; mix the glycerine and the water, and digest the wild cherry in 8 oz. of the mixture for 4 days; pack in a percolator, and pour on the remaining 4 oz. glycerine and water; when this has disappeared from the surface, pour on rectified spirit (0·817) until 12 oz. of fluid have been obtained, and set this portion aside. Then percolate with spirit until 20 oz. more have been obtained; evaporate to 4 oz., and mix with the reserved portion.

Cinchona.—(1) 16 oz. yellow cinchona bark in coarse powder, sufficient distilled water, 1 oz. rectified spirit; macerate the bark in 40 oz. water for 24 hours, pack in a percolator, and add water until 240 oz. have passed through, or until the bark is exhausted; evaporate the liquor to 20 oz. at a temperature not exceeding 160° F. (71° C.); filter, and continue the evaporation to 3 oz., or until the sp. gr. of the liquid is 1·200; when cold, add the spirit gradually, constantly stirring.

(2) Resinous.—(*a*) 4 oz. any variety of cinchona bark in powder, 24 fl. oz. proof spirit; prepare a tincture by displacement; distil off most of the spirit, and evaporate the residue to the consistence of an extract.

(*b*) 1 lb. Peruvian bark, 4 pints rectified spirit; make 4 pints of tincture by displacement; add water to the mass in the percolator; digest and obtain 6 pints of infusion; distil off the spirit from the tincture, and evaporate the infusion to the consistence of syrup, then mix the two, and complete the evaporation.

(*c*) 2 lb. yellow bark, 4 fl. dr. hydrochloric acid, 1 gal. water; boil, strain, and repeat the decoction with fresh water and acid; mix the decoctions, filter, and agitate with 2¼ oz. fresh slaked lime; filter or decant, dry the residue, and exhaust with q.s. hot alcohol; evaporate the alcoholic tincture to a pilular consistence.

Colocynth.—(1) Colocynth pulp,

cut in pieces and the seeds removed, simply macerated in cold water for 36 hours, frequently pressing it with the hands, and afterwards strongly pressing out the liquor, which must be strained before evaporating.

(2) Compound.—(*a*) 6 oz. colocynth free from seeds, 12 oz. extract of Socotrine aloes, 4 oz. scammony or resin of scammony in powder, 3 oz. hard soap in powder, 1 oz. cardamoms free from capsules in fine powder, 160 oz. proof spirit; macerate the colocynth in the spirit for 4 days, press out the tincture, distil off the spirit, and add to it the extract of aloes, soap, and scammony; evaporate the residue by a water bath to a pilular consistence, adding the cardamoms towards the end of the process.

(*b*) 18 lb. Turkey colocynth boiled in about 20 times its weight of water for 5 or 6 hours; to the strained decoction add 40 lb. hepatic aloes, which are boiled until dissolved, when the solution is decanted. In the meantime the colocynth is exhausted with a second quantity of water (less than the first), and the strained liquor is added to the undissolved residue of the aloes, and boiled for a few minutes; after which it is drawn off and mixed with the first decoction of aloes; the mixed liquors are allowed to stand until quite cold (say next day), to deposit the resinous portion. The liquor is decanted or drawn off, and set evaporating as quickly as possible; as soon as a treacly consistence is arrived at, the whole is allowed to cool considerably, and 4 lb. clean moist sugar and 10 lb. Castile soap (previously melted with a little water) are added; 6 lb. powdered scammony is next gradually sifted in, the extract all the time being assiduously stirred by a second person. Lastly, the heat is further moderated, and the stirring continued until a rather harder consistence is acquired than is proper for the extract, when the steam is wholly shut off, or the vessel removed from the heat. As soon as the whole has become sufficiently cool to prevent any considerable evaporation of the spirit, 1 qt. essence of cardamoms is expertly stirred in, and the extract at once (whilst still warm) put into stone jars or pots, and tied or covered over.

Gentian.—3 lb. sliced gentian root, 4 pints temperate distilled water; macerate for 12 hours, and gently express the liquor; repeat the maceration with 1 qt. water for 6 hours, and evaporate the mixed liquors.

Hellebore.—2 lb. powdered black hellebore, ½ lb. salt of tartar, 7 pints dilute alcohol (sp. gr. 0·935); digest 12 hours, and express the tincture; add to the marc 7 pints white wine; digest for 24 hours, express, mix the tincture, filter, and evaporate.

Hops.—(1) 8 oz. hop, 15 oz. rectified spirit, 80 oz. distilled water; macerate the hop in the spirit for 7 days, press out the tincture, filter, and distil off the spirit, leaving a soft extract; boil the residual hop with the water for 1 hour, express the liquor, strain, and evaporate on a water bath to the consistence of a soft extract. Mix the 2 extracts, and evaporate at a temperature not exceeding 160° F. (71° C.) to a pilular consistence.

(2) 2½ lb. commercial hops, 2 gal. boiling distilled water; macerate for 24 hours, boil to 1 gal., strain whilst hot, and evaporate to a proper consistence.

Jaborandi.—Fluid. 16 oz. jaborandi leaves in moderately fine powder, sufficient of alcohol (50 per cent.); moisten the powder thoroughly with the menstruum, pack in a conical glass percolator, place a layer of 2 in. well-washed sand on the top of the cloth covering the material, add menstruum until the liquid begins to drop from the percolator; then close the lower orifice with a cork, and securely cover the percolator; set aside in a moderately warm place for 4 days. At the expiration of this time, remove the cork, and add more menstruum by degrees until the material is exhausted. The first 14 oz. of the percolate are reserved, and the remainder evaporated in a water bath, with constant

stirring towards the close, to 2 fl. oz., and added to the reserved portion. If the percolation and evaporation have been properly performed, the fluid extract will not require to be filtered.

Jalap.—(1) 1 oz. jalap in coarse powder, 5 oz. rectified spirit, 10 oz. distilled water; macerate the jalap in the spirit for 7 days, press out the tincture, filter, and distil off the spirit, leaving a soft extract; again macerate the residual jalap in the water for 4 hours, express, strain through flannel, and evaporate by a water bath to a soft extract; mix the two extracts, and evaporate at a temperature not above 140° F. (60° C.) to pilular consistence.

(2) 2½ lb. powdered jalap; 1 gal. rectified spirit; digest 4 days, and express the tincture; boil the marc in 2 gal. water until reduced to ½ gal.; filter the tincture and decoction separately, and let one distil and the other evaporate until each thickens; mix the two, and complete the evaporation.

Juniper.—Macerate juniper berries in water at 77° to 86° F. (25° to 30° C.) for 24 hours; strain, repeat the process with a fresh quantity of water, mix the liquors, filter, and evaporate.

Malt.—(1) An infusion of malt is made in water at 160° to 170° F. (71° to 77° C.), drained off without pressure, and evaporated to a honey-like consistence. The quantities are—1 pint crushed malt in 3 pints hot water, and the infusion occupies about 4 hours.

(2) 47½ oz. extract of malt, mixed with 1 oz. iron pyrophosphate and ammonia citrate dissolved in 1½ oz. water.

(3) 6 oz. coltsfoot leaves, 6 oz. spotted lungwort, 8 oz. liquorice, 2 lb. stoned raisins, 6 gal. old strong ale, not "hopped"; boil down to 4 gal., express strongly, and evaporate to honey-like consistence.

Meat.—1 oz. lean meat, recently killed, chopped very small; 8 oz. cold water; shake well together for 10 minutes; heat gradually to boiling; tie simmer gently for a few minutes; strain through a hair-sieve whilst still hot; evaporate to a soft mass. 1 lb. meat yields barely 1 oz. (Liebig.)

Myrrh.—Compound. 2 oz. myrrh, 2 dr. gum-arabic powder; triturate, add water enough to form a thick emulsion, and 4 oz. extract of couch-grass.

Nux Vomica. — Alcoholic. (1) Soften nux vomica by steam, dry rapidly, and reduce to fine powder; boil with rectified spirit until exhausted; strain, distil off the spirit, and evaporate to the consistence of a soft extract.

(2) 8 oz. nux vomica seeds, 3 pints rectified spirit; expose the seeds to steam until softened, then bruise, slice, dry, and macerate them in ¾ of the spirit for 7 days; express the tincture and repeat the maceration with the remaining ¼ of the spirit; again express the liquid; filter the mixed tinctures, distil off the greater part of the spirit, and complete the evaporation by a gentle heat.

Opium.—(1) 1 lb. opium in thin slices, 6 pints distilled water; macerate the opium in 2 pints of the water for 24 hours; express the liquor. Reduce the residual opium to a uniform pulp, macerate again in 2 pints of the water for 24 hours; express; repeat the operation a third time; mix the liquors, strain through flannel, and evaporate by a water bath to pilular consistence.

(2) 1 oz. opium, 1 qt. distilled vinegar; digest 2 days with heat; decant, filter, evaporate.

(3) 4 oz. opium, 4 oz. sugar, 1 qt. water; rub together, and keep the mixture loosely covered in a warm situation, about 70° F. (21° C.), for 10 days or more; add 1 qt. cold water; next day filter, and evaporate.

Orris.—3½ lb. orris root (cut small and bruised), 4 pints rectified spirit of wine; percolate several times, and lastly filter.

Poppies.—(1) 16 oz. capsules coarsely powdered, 2 oz. rectified spirit, sufficient distilled water; mix the capsules with 40 oz. of the water, stirring frequently for 24 hours; pack in a perco-

lator; pass water slowly through until about 160 oz. have passed; evaporate by a water bath to 20 oz.; when cold add the spirit; after 24 hours, filter, and evaporate to a pilular consistence.

(2) 15 oz. bruised poppy-heads without the seeds, 1 gal. boiled distilled water; macerate 24 hours, boil to ½, strain, and complete the evaporation.

Tolu.—1 oz. balsam of tolu, 1 pint rectified spirit of wine; digest four days, shaking now and again, then filter.

Quassia.—1 lb. scraped quassia, sufficient distilled water; macerate the quassia in 8 oz. of water for 12 hours; pack in a percolator; add water till the quassia is exhausted; evaporate, filter before it becomes thick, and again evaporate in a water bath to a proper consistence for pills.

Rhatany.—1 oz. rhatany in coarse powder, 15 oz. cold distilled water; macerate 24 hours in 2 oz. of the water; percolate the whole; evaporate by water bath to dryness.

Rhubarb.—(1) 8 oz. sliced or bruised rhubarb, 5 oz. rectified spirit, 50 oz. distilled water; macerate 4 days; strain, and set to subside; decant the clear, strain, mix, and evaporate to a proper consistence over a water bath at 160°F. (71°C.).

(2) Compound.—3 dr. extract of rhubarb, 1 dr. extract of aloes, softened with 4 dr. water; evaporate to an extract; dry in a warm place, and powder.

(3) Fluid.—Mix 8 oz. rhubarb in coarse powder, with bulk coarse sand, and moisten with dilute alcohol (sp. gr. 0·935 = 13 u.p.) to form a pasty mass; in a short time introduce it into a percolator, shake until uniformly settled, cover with cloth or paper; pour on the rest of the spirit (the remainder of 2 pints) until the product has little odour or flavour of the root; gently evaporate the tincture to 5½ fl. oz., and add 5 oz. sugar, when the whole should measure 8 fl. oz.

Sarsaparilla.—(1) Alcoholic. (a) 16 oz. bruised sarsaparilla, 2 oz. bruised liquorice root, 2 oz. rasped guaiacum wood, 2 oz. sliced sassafras bark, 6 dr. sliced mezereon, 7 pints spirit (sp. gr. 0·935 = 13 u.p.); digest 14 days, express, filter, evaporate to 12 fl. oz., add 8 oz. sugar; as soon as this is dissolved, withdraw the heat.

(b) 16 oz. sarsaparilla, 2 oz. liquorice root, 2 oz. sassafras, 360 gr. mezereon, all in fine powder; 4 oz. glycerine, 8 oz. rectified spirit, 4 oz. water; macerate in a closed percolator for 4 days; let the percolation commence, and finish it by adding diluted alcohol (equal volumes of alcohol at 0·835 and water) until 2 pints have been obtained. Reserve the first 12 oz., having added 4 oz. glycerine to the remainder of the percolate, which evaporate to 6 oz., and mix with the reserved portion.

(c) 16 oz. Jamaica sarsaparilla cut transversely, 280 oz. distilled water at 160° F. (71° C.), 1 oz. rectified spirit; macerate in ½ the water for 6 hours, and decant the liquor; digest the residue in the remainder of the water for 6 hours more, mix the liquors, express, and filter; evaporate by a water bath to 7 oz., or until it has a sp. gr. of 1·130; when cold, add the spirit.

Scammony.—(1) Powdered scammony exhausted with proof spirit and the resulting tincture distilled until little but water passes over; the remaining water is then poured from the resin, which is next well washed in boiling water and dried at a temperature below 240° F. (115½° C.).

Senna.—(1) Alcoholic. 1 oz. senna in powder, 5 oz. rectified spirit; heat gradually to boiling; let cool; in 24 hours express, strain and repeat the process with fresh spirit; distil, and evaporate.

(2) Fluid.—2¼ lb. senna in coarse powder, 65 fl. oz. proof spirit; macerate 24 hours; proceed by displacement: subsequently add weak spirit (1 of rectified spirit to 8 of water) until 10 pints of tincture is obtained; evaporate to 1 pint, filter, add 2½ oz. sugar and 1 fl. dr. oil of 'anise' dis-

solved in 2 fl. dr. compound spirit of ether.

Squills.—Acetic. Digest 1 lb. powder of squills in 3 oz. acetic acid, and 1 pint distilled water, with a gentle heat for 48 hours. Express strongly without straining; evaporate to a proper consistence.

Stramonium.—(1) Pack coarsely-powdered stramonium seeds in a percolator; pass about their own weight of washed ether slowly through; remove the ether, and set aside; pour over proof spirit until the seeds are exhausted; distil off the spirit; evaporate the residue by a water bath to pillular consistence.

(2) 15 oz. stramonium seeds, 1 gal. boiling distilled water; macerate for 4 hours in a vessel lightly covered, near the fire; afterwards take out the seeds, bruise them in a stone mortar, and return them to the liquor: then boil down to 4 pints, strain whilst hot, and evaporate.

Taraxacum.—Crush fresh dandelion root, press out the juice, and allow it to deposit; heat the clear liquor to 212° F. (100° C.), and maintain the temperature for 10 minutes; then strain, and evaporate by a water bath at a temperature not exceeding 160° F. (71° C.) to a proper consistence.

Tobacco.—Alcoholic. 1 lb. tobacco leaves, 2 lb. spirit (sp. gr. 0·900); digest in a warm place for some days, express strongly, and again digest in a mixture of 1 lb. each of water and spirit (0·900) for 24 hours; again press out the liquor and evaporate the strained and mixed liquors in a vapour bath at a temperature not exceeding 167° F. (75° C.).

Valerian.—Fluid. 12 fl. oz. rectified spirit; mix, add 8 oz. valerian in coarse powder, digest and percolate, adding subsequently spirit (at or near proof) until 16 fl. oz. of tincture have passed through; let this evaporate spontaneously, in a shallow vessel, until reduced to 5 fl. oz.; in the meantime add fresh spirit to the mass in the percolator until 10 fl. oz. more of the tincture are obtained, which add to the above residue of the evaporation, dissolving any oleo-resinous deposit in a little rectified spirit, and adding it to the rest; filter, and add sufficient rectified spirit to make the whole measure 16 fl. oz.

PETROLEUM HEATING AND LIGHTING APPLIANCES,

THEIR CARE AND MANAGEMENT.

THERE are two well-known appliances answering to this description, these being the "Primus Stove" and the "Wells Light." As so many enquiries come to the editor's notice for information relating to the working parts and the repair of these types of heating and lighting apparatus, particularly from the Colonies and remote places, it is thought that the description of their working principle will be of interest.

In both these appliances the effect is obtained by forcing a more or less fine stream of petroleum (or paraffin) through a nipple, this combustible fluid having first passed through hot tubes which causes the oil to become more or less a vapour, which burns freely (which the cold petroleum will not do). The tubes in which the petroleum is thus volatilised into a vapour form part of the burner, so that the heat of the burning material, besides doing the work required of it, volatilises the petroleum as it approaches the burner outlet. The force which causes the petroleum to leave the container or body of the lamp, and travel up and through the heated tubes to the burner nipple, is compressed air, air being compressed into the body of the lamp where the petroleum already is. Fig. 100, which is a sectional illustration of the "Primus" stove, shows this. The body of the lamp has a filling cap, shown at the left side (through which the oil is poured as with an ordinary lamp) this cap being provided with a small valve which allows of the compressed air being discharged whenever the lamp requires replenishing with oil, also at any time that the flame requires to be extinguished (stopped really). On the right of the body will be seen the pump (lying horizontally) by which air is pumped into the body when the lamp is required for use or if the flame goes down and requires increasing. The burner tube, it will be noticed, extends down, inside the body, to as close to the bottom as will admit of the oil passing

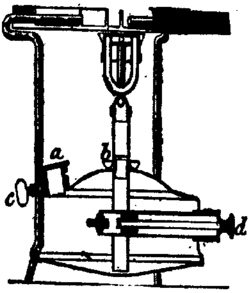


FIG. 100

into it. This prevents any air passing up to the burner from the body until the oil is exhausted. The burner nipple therefore delivers petroleum vapour wholly, not an admixture of petroleum and air. Figs. 101 and 102 illustrate a not-quiet burner and a quiet burner respectively.

FIG. 101.

FIG. 102.

The following are the customary directions for using this stove.

Filling.—Unscrew the lid *a* and fill the tank about three-fourths full with petroleum, when the lid should be screwed down air-tight.

Heating.—Fill the cup *b* under the burner with methylated spirits; light spirits; shut valve *c*.

Lighting.—If the stove is not ex-

posed to any draught it will light itself without pumping before the spirits in the cup are burned out. Should in some cases the spirits burn out before the stove gets alight, give a few gentle strokes with pump handle *d* till the petroleum vapour issues from the burner, when it should be lighted immediately at the burner top with a match held in readiness for the purpose.

When the burner is hot from previous use the stove may be lighted in the same manner, without methylated spirits, but it is advisable not to pump hard till the blue colour of the flame shows that the burner is hot enough to evaporate the oil entirely, otherwise relight the stove with methylated spirits in the cup.

Draughts of air should be avoided when the stove is being lit.

To Increase the Flame.—After the spirits in the cup *b* are entirely consumed work the pump *d* for some time until high pressure is obtained. No fear need be entertained of pumping too hard as each stove is tested under high pressure and the stove works best when pumped up hard.

To Decrease the Flame.—This is done by quickly opening the valve *c* and letting the air rush out until the flame is sufficiently lowered, when the valve is quickly closed again.

Extinguishing.—In order to extinguish the flame, open the valve *c* about one turn and leave it open. When the stove is not in use, it is important that the valve *c* should be left open and the pump handle *d* should not be touched.

Clean the mouth-piece each time the stove is to be lit, by inserting the accompanying cleaning pin a few times.

Should the stove appear to be out of order one of the following details will be found to apply.

The nipple, Fig. 103, may become blocked by particles of food, charcoal, etc., which are easily removed by the cleaning pin (Fig. 104). The pin is, however, sometimes broken in the nipple, or the hole in the nipple may become too wide, through the necessary frequent cleaning operations. In the latter case the flame is red and smoky, and the nipple must be removed. This is done in case of burners not open at the top, with a revolving spanner, as shown in Fig. 105, and in the manner shown in Fig. 106. Burners with open tops, can have the nipple taken out or fixed by a straight spanner, Fig. 107. No packing is used for the nipple, but it is necessary to screw it down air-tight.

FIG. 103.

If the flame is not blue and atmospheric after a new nipple has been fixed, the burner should be examined.

FIG. 104.

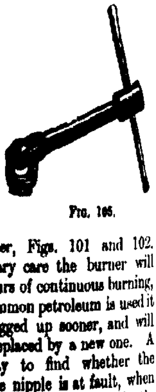


FIG. 105.

The burner, Figs. 101 and 102. With ordinary care the burner will last 1000 hours of continuous burning, but when common petroleum is used it may get clogged up sooner, and will have to be replaced by a new one. A practical way to find whether the burner or the nipple is at fault, when the stove does not give a sufficiently large flame, is to empty the tank, then unscrew the nipple and fill up the hole air-tight with a stopper supplied for the purpose. Pump the tank full of air and remove the stopper from the burner. If the air then rushes through the burner, throwing out sundry small particles, the fault is with the nipple, which must be cleaned or renewed. If, however, the air does

not rush out freely, or not at all, the fault is with the burner, and a new one will have to be fixed. The burner

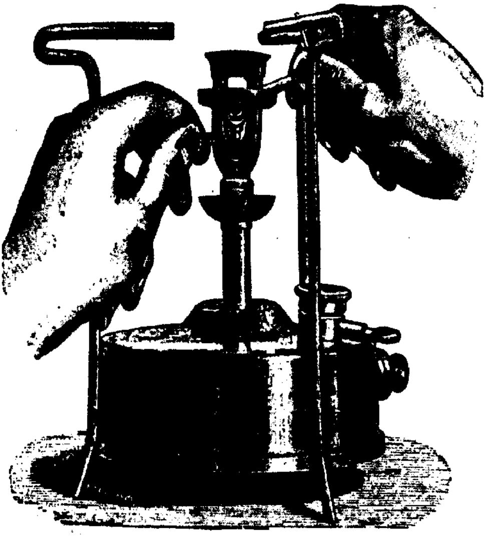


FIG. 106

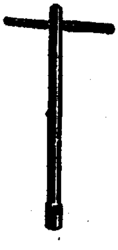


FIG. 107.

FIG. 108.

is easily unscrewed and a new one fixed by an ordinary spanner. The asbestos washer round the screw of the new burner should be soaked in water, and the burner screwed well down, so as to prevent any escape of air

The pump, Fig. 108. As for the pump, the only part likely to require repair is the pump leather, Fig. 109, which may become hard or wear out. If it cannot be softened with the aid of a little oil or petroleum, the old leather can be unscrewed and a new one fixed. The pump piston can be taken out for oiling, etc., even when the stove is burning. Should it, in

FIG. 109.

FIG. 110.

rare cases, be found that petroleum escapes through the pump, empty the lamp and pull out the piston. The pump valve, Fig. 110, at the bottom of the pump cylinder is unscrewed by

a straight spanner *a*, as shown in Fig. 111, and a new valve fixed, taking care that the lead packing is in its place at the bottom of the cylinder. If a new lead washer is used, see that the old one is first removed. Above refers to the kind of valve introduced during the early part of 1897. The old pattern pump cylinder is not permanently fixed, and can be entirely unscrewed by a spanner or tong. The spring valve at the end of the old pump or

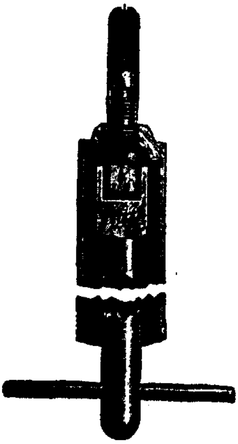


FIG. 111

the rubber packing can then be adjusted or replaced by a new one.

Any escape of air would cause the flame continually to go low as soon as one ceases to pump, as the air-pressure in the tank would, in such a case, not be maintained. Any escape can be discovered by filling the tank with compressed air, as described above (see "Burner,") and holding it under water; the bubbles rising through the water will show the spot whence the air escapes, and which then should be soldered. It is advisable in such cases to withdraw the pump shaft, so as to prevent the leather from getting wet and afterwards hard.

In case of any leakage through the filling lid the rubber washer is easily renewed.

These particulars will be found to apply to practically all these stoves whether used for boiling purposes or paint burning or brazing lamps or plumbers' furnaces.

The "Wells Light."—Fig. 112 gives the details of this apparatus as ordinarily used, the later illustrations showing special details.

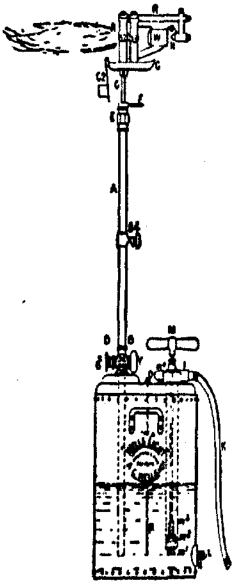


FIG. 112.

To Fit up Lamp when New.—First see that there is no dirt in the large iron pipe A, or in the mouth of the oil valve B, then screw them together locking the pipe by the jam-nut D by hitting it lightly with a spanner or hammer. A thin piece of hemp or string must be put between them to make a joint. At top of pipe A is a stuffing-box E, and by means of handle

F, the packing ring (which must sometimes be renewed, when worn) is slackened or contracted. Having eased the handle, place the burner on the lamp by forcing the tube G down into the stuffing-box. (See that the lip on the dish C is towards the jet as shown. This lip catches any oil that leaks from the jet and runs down the wind guard T.) Upon valve B will be found a place to affix the small pressure gauge sent. Affix the short length of suction hose K to the projection on pump at I. The strainer at the end of the hose must be kept clean.

To Charge the Lamp with Oil.—Close the valve B^2 and open air-plug O. Put the hose into a cask or bucket of oil, and pump until the lamp is about three-quarters full, not more. This can be ascertained by withdrawing the gauge-rod P and noting the oil mark. This rod does not go quite to the bottom of the tank, but only level with the feed pipe. Then screw down plug O, take hose-pipe out of oil cask, and pump air into the lamp till the gauge shows 20 lb. pressure. The air being compressed into the body of the lamp forces the oil (when the tap B^2 is opened) up the feed tube and through the burner tubes R, where it is heated and turned into gas and issues from the jet N.

To Light the Burner.—When the charging is done the burner must be heated before attempting to light up (unless the new self-lighting arrangement is used, see later). Fill the dish C with paraffin or any burning oil and put some waste or asbestos in it to start the flame. Put the lighting chimney S, Fig. 113, over the burner to draw up the flame, also the back-guard T to catch any oil that may leak from the jet and carry it into the dish where it assists in heating the burner. After it has burnt about 10 min. turn on the tap and let a little oil—very little—through and, if hot enough, the burner will begin to generate gas. Never open the tap until the burner is well heated, as if the burner is filled with cold oil it takes longer to heat. Do not remove the chimney until the flame is clear and makes a rushing sound. At any time, if by accident or carelessness the lamp goes out, or spits oil, through getting cold, use the chimney as described to heat up again; but if the oil is still warm in the tubes it is not necessary to use waste in the dish, as the burning oil will gradually heat up again. Another

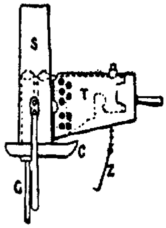


FIG. 113.

way of lighting the lamp is to take the burner off and place it in any convenient fire, but this requires care or the burner will overheat and crack. When hot replace the burner, lock up the stuffing-box handle, and then turning on a very small supply of oil by the valve B^2, Fig. 112, light the gas at the jet N. If it is not hot enough to start, place the lighting chimney over the tubes for a few moments. A small hand lamp is sent, and it is advisable to keep this always burning near the lamp so as to be ready to relight the moment the lamp goes out from any cause. If the flame is jerky regulate by the valve B^2 until the proper oil feed is ascertained. Keep the backguard T (Fig 113) always on. Keep the jet hole N, clear by using the small pricker Z. The light can be turned round so as to make the flame run with the wind.

Working the Lamp.—The starting pressure is 20 lb., except when it is required to run for long periods without re-pumping, or when the burner is elevated (see later) in which cases the pressure may be greater. As the oil is consumed, the pressure reduces. When it has fallen to 7 lb., it must be increased

by pumping. The lower the pressure, above 7 lb., the less oil there is burned. In high winds the pressure should not go below 15 lb.

The oil can be replenished at any time without stopping the light, by putting the hose-pipe into a bucket or cask of oil and working the pump, keeping the plug O screwed down. This operation raises the pressure. The quantity of oil used can be judged from the following :—

No.	1	burner uses	$\frac{1}{2}$	gal.	per hr.
,,	2	,,	$\frac{3}{4}$	,,	,,
,,	3	,,	$1\frac{1}{4}$	,,	,,
,,	4	,,	2	,,	,,

The foregoing directions apply generally when using either the special coal-tar oil supplied by the makers of the lamp, or when using petroleum or kerosene, but with these two latter the backguard should be a plain one instead of the more ordinary perforated one shown at T, Fig. 113.

Cause of Failure in Working a Lamp successfully.—A burner being dirty in its passages, not allowing the oil to pass through them. The main jet hole N, Fig. 115, being obstructed by tar. This causes the flame to splash sideways outside the burner tubes. It can be put right instantly by pricking it with the needle affixed by chain to each backguard, the little holes in the body of jet being stopped up. These little holes are smaller than the main jet, and will not allow anything to pass large enough to stop it up, and they want cleaning out every day. Soot may form on the burner tubes or in the air cone W, lowering the generating power. This must be knocked or brushed off. The oil filtering gauze, see Fig. 114, may be stopped up with dirt from the oil, and thereby not allowing sufficient pressure to go to the burner. If the light keeps bobbing, it shows the oil feed is turned on too much. Should the pressure gauge not stand when the lamp is pumped up and left, it would show there was air leakage in the lamp body which can be easily caulked, or else in the pump. The pump, which is of the simplest construction, can be taken out and repaired, or sent back to the makers. If the oil or air runs back from the pump and leaks out of the hose K, it

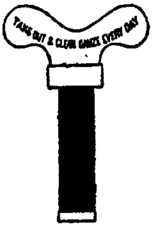


FIG. 114.

shows that there is something between the clack leather M¹ and its seat. Take the pump out (by tapping projection M⁴), unscrew the two small screws at the bottom, and the leather can be taken out and examined, and renewed if necessary. If the pump does not suck oil properly, it shows that something is wrong with the cup leather M². Take the pump out, first unscrewing the handle M. Unscrew the bottom clack casting bodily, then draw the bucket and rod out through the bottom. Be careful to replace the distance piece M³ when replacing parts. It is of vital importance that there should be no air leakage. Be careful that no rubbish accumulates in the stand pipe A, by old gland rubbers getting worn out and dropping down, or it will stop up the top of the oil feed-valve. Remove the standpipe and clean occasionally.

It is important that the parts be kept clean. Remove the gauze plug Y shown in Figs. 112 and 114, every time of working, wash or blow the dirt out of the gauze and replace; this is very important, a lamp will not work without this, it acts as a regulator and dirt filter, and if this is not done every time of using, the dirt in the oil accumulates and stops the pressure. Before removing the gauze plug it is necessary to let all the pres-

sure out of the lamp, or it will squirt the oil out. This is done by unscrewing the plug O. It is necessary sometimes to clean out any accumulation of sediment from the bottom of the tank. To do this, unscrew hose K from I and screw it on to H; slack out plug L and the pressure will force the oil through the hose into a bucket. This saves tilting the lamp up.

Cleaning Burner, etc.—This is the most important matter in the whole lamp, as without a clean burner, pure white lights cannot be obtained. Burners should be cleaned every 12 hours or so, and they will be found much easier to clean than if allowed to run longer. Give the lamps into the charge of one man, and have the burners cleaned systematically. This saves much trouble in the end. We much recommend a spare burner with each lamp, in case of failure, through carelessness in cleaning or breakage, and if one is always kept clean, it is ready for use at the moment when a lamp is required. To clean the dirty burner, take it off the lamp and remove the dish C by slacking out the set screw underneath it. Next remove all the plugs with a spanner, by giving it a sharp knock with the hand; this will be found to unset them easier than a steady pressure. Bore out the hard deposit in the tubes by means of steel drill sent, and see that the dirt falls out as bored away. Do not drive the drill in, but humour any hard bits gently, and cut them away. When the drill is worn blunt, have it flattened out to proper width and re-ground. Clean the cross passages also in burner. Remove the jet, Fig. 115, and clean this inside, also see all the small holes are clear and the main jet hole N, but this latter must not be rhymered out, as it is very important that the hole should be kept the same size. Screw the plugs tightly into their places again, covering the threads with Wells' special plug paste, supplied in tin boxes, to preserve them from tar and prevent binding. Then after blowing through the burner with the mouth (or dry steam), screw the jet back into its place.

New Self-Starting Arrangement.—This is as Fig. 115, and is now fitted to all lamps sent out. The directions are as follows: Fill the lamp with oil as already explained and pump the

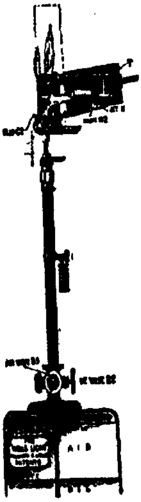


FIG. 115.

pressure up to 30 lb., keeping all valves closed. It is well not to fill the lamp more than half-full of oil to begin with; the less oil in the tank the greater body of air there will be for use in lighting. More oil can be pumped in afterwards. Raise flap C^1 so that it lies against the burner tubes as shown. If the lamp is being used in a very exposed position or in high winds put on the chimney; under ordinary circumstances the use of the chimney may be dispensed with. Place the small piece of waste W^1, soaked in oil, in the backguard T and light it. This acts as a leader to keep the burner alight while heating up.

The Starter.—Hang small can on to

escape valve B^4 and open same; open the oil valve B^2 slightly, allowing the oil to rise gradually in the standpipe until it reaches the level of B^4; then close valve B^2, and when the oil has ceased to flow through B^4, close that also. There will now be the right height of oil in the standpipe for starting. Now open air tap B^3 very slightly, and the air passing up through the oil in the standpipe will carry it up and out of the burner jet N, where it will be ignited by the waste in the backguard, and burn in a strong hot flame as shown. After about 1½ minute this flame will begin to grow small, showing that the column of oil in the standpipe is becoming exhausted; then turn the oil valve B^2 a little, allowing more oil to pass up into the standpipe. Regulate the flow of air and oil by the valves until the flame is clear and smokeless. Watch the pressure gauge and work the pump if the pressure falls below 10 lb. After 3 or 4 minutes the burner will be hot; then close the air valve, open the oil valve more fully, and when the flame is clear and roaring take off the chimney and lower the flap.

Use of the Flap.—If at any time the burner becomes cold or spits oil, either by reason of the vapour jet N being stopped or the generating tubes being dirty, raise the flap. This will spread the flame on to the tubes and heat them up again, and also cause any dropping oil to fall into the dish.

In working the lamp when once started do not raise the pressure above 20 lb.; a greater pressure is wasteful.

Putting Lamp out.—The new starting arrangement enables air to be blown through the burner at the end of the run. This has a good effect in lessening deposit of carbon. It is carried out as follows: close the oil valve B^2, hanging the small can on B^4, and open B^4, thus emptying all the oil above it. Then open valve B^3 slightly, and this will blow the oil remaining in standpipe out through B^4. Then close B^4 and the remainder of the air in the tank will pass out through the burner, issuing through the jet in a blue cloud. It is important that the oil in the standpipe be first drawn off, so that the air passed through the burner may be dry and not impregnated with oil.

Wells Light with Swivel-Mast.—This is illustrated at Fig. 116, with detail of burner at Fig. 117. The pur-

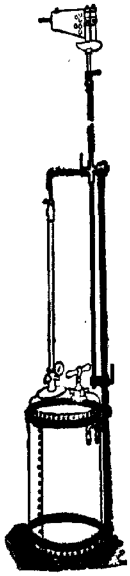


FIG. 116.

pose of the high upright tube or mast is to enable the light to be raised 12 ft. from the ground. The directions are as follows.

After fixing the hoops on the tank with the joints over riveted seam, drop the mast into the two rings, connecting at the same time the gland on the top of the standpipe with the gland on the swivel-mast, by means of the short bent tube sent. Lock up the gland handles.

Lower mast to horizontal position,

and place the burner in the top gland. Have the burner jet uppermost, and keep it so by screwing the gland up tightly.

Put some waste, soaked with paraffin, in the lighting bucket sent with the swivel-mast, and place it under the burner, which will now be supported by the bucket and its crutch as shown in Fig. 117.

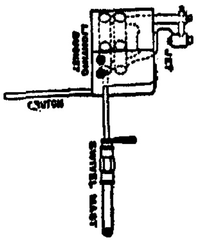


FIG. 117.

Light the waste, and after 7 or 8 minutes turn on a little oil and a little air at each of the wheel taps (supplied on the latest style of lamps). When the flame is clear and gas generates properly, put on the backguard, turn on more oil, shut off the air tap entirely, and slowly lift the mast out of the bucket to its vertical position. If raised too fast, the oil will not be able to ascend the tube quick enough, and the supply to the burner will be cut off, causing the light to go out. Do not let the bucket fall, or it may be bent.

Always put out the light by closing the tap, never by letting off pressure, as sudden contraction injures the burner. Before lighting up next night empty the pipes of oil, by letting off pressure and opening the tap, when the oil will run down into the tank. Close tap before pumping up.

THE PHONOGRAPH.

(*See also* THE TELEPHONE for further description of Sound Vibrations and the action of these vibrations on diaphragms.)

THOUGH scarcely necessary at this day, a brief description may be given of the acting principle of the phonograph or sound recorder and reproducer.

Sound consists of a series of vibrations, following one another with great rapidity, yet each separate, so that it is possible to obtain a perfect record of them. If a record cylinder of a phonograph be examined under a high-power magnifying-glass, it will be seen that the recorded sounds represent indentations of varying depths and lengths, as Fig. 118 shows.

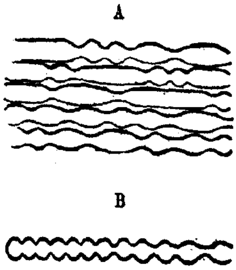


FIG. 118.

A is a piece of a cylinder showing the channels or grooves cut by the recording jewel, the bottom of each channel showing irregularities due to sound vibrations. B shows a portion of the face in plan, but magnified to a less degree than A.

These irregular indentations are wholly due to the vibrations of the diaphragm, when receiving the voice, causing the recording or cutting jewel to rise and fall. Sound vibrations with the greatest force cause the deepest

indentations, while vibrations of greatest length cause the largest indentations.

Understanding, therefore, that the sound vibrations, whatever they may

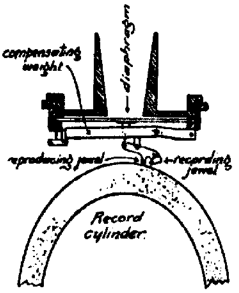


FIG. 119.

proceed from, cause a prepared diaphragm to vibrate, this in turn causing a cutting-point to record the strength and length of the vibrations on a wax cylinder, it would follow that a suitable instrument, made to travel over the lines thus made, will reproduce the vibrations and the sound they represent. This is exactly what happens, but in the earlier instruments there was one diaphragm, and its parts, to record the sound, while a different one was used to reproduce it. With the Edison-Bell "Standard" phonograph, now being widely used, the one diaphragm is made to serve both purposes, and this it does very successfully.

Fig. 119 is a section of the diaphragm and parts. The recording or cutting jewel is on the same arm as the reproducing jewel,* but at no time can both touch the record cylinder at once. By the simple movement of a small arm either jewel can be thrown into action in a moment, the reproducer when a record is to have its sound vibrations reproduced, the recorder when a plain cylinder is put on ready for a record to be cut on it.

The description issued by the Edison-Bell Consolidated Phonograph Co., Ltd., is as follows.

Fig. 120 shows the complete machine with all parts marked for reference.

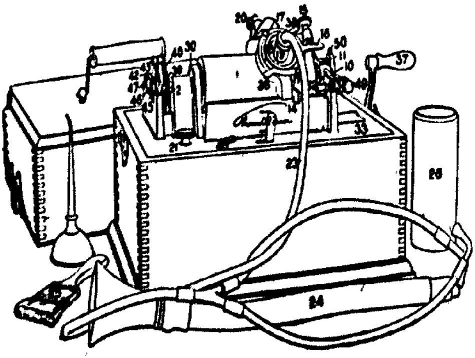


FIG. 120.

To Make a Record.—Raise the cam lever (No. 14 on Fig. 120) till its end rests on edge of bar, thus raising point

* The term "stylus" is often applied to these parts. The word jewel is used because the points are made of a hard crystal stone or jewel.

of the stylus clear of the cylinder. Open gate (No. 12, Fig. 120) wide, place wax cylinder, bevelled end foremost, upon the tapering mandrel, 1, and press it home firmly, but not too forcibly, then close gate.

Slide arm to beginning of cylinder. Draw diaphragm arm, 16, down as far as it will go. Connect speaking tube, 24.

Start machine by pushing starting-lever, 22, to left, lower cam, 14, as far as possible. The recorder point will now be cutting into the wax, and emitting a soft hissing sound through the speaking tube. Hold the tube within half an inch of the lips, and give your dictation in a clear and distinct tone of voice.

Should it be necessary to pause during the dictation, and before the end of the cylinder has been reached, stop machine by pressing starting-lever 22, to the right, so as to save wasting surface, while collecting your thoughts, and press back again when you have decided upon the word, phrase or sentence you desire to record.

To Reproduce a Record.—A fine white shaving will appear on the surface of the cylinder where it has been passed over by the recording stylus. Remove the speaking tube, raise the arm, 18, slide it as far to the right as possible, and, then, throwing it right back, set the machine in motion, and dust off the shavings by holding the camel-hair brush against the cylinder whilst revolving, and passing it slowly from left to right; also gently brush the styluses to free them from the wax gathered upon them whilst recording. Stop the machine. This operation being completed, the record, as it is now called, is ready for reproduction, so press diaphragm arm (No. 16, Fig. 120) up against the point of the adjusting screw, 15, thus bringing reproducing point into play, slide speaker arm to left and, lower it, so that centre of diaphragm is a little to the left of the commencement of the record, attach horn or hearing tube, and start the machine.

Note.—It is important to notice that the speaker arm can only be thrown right back when it is at the right hand end of the mandrel. If

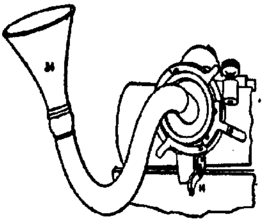


FIG. 121.

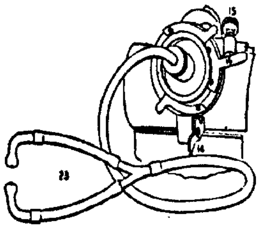


FIG. 122.

thrown back at any other position it is apt to fall with a jar which may injure the diaphragm.

To Make Reproduction Clear.—Whilst listening with the hearing tube, or with the horn, press the diaphragm arm, 16, upward with the thumb of the right hand, and with the first and second fingers of the same hand turn the adjusting screw slowly until you can hear the record distinctly.

The reproducer usually adjusts itself to the track or groove made by the stylus, but it sometimes occurs that a clear reproduction is not at first obtained. This adjustment will bring the reproducer into the groove of the record.

To Shave Cylinders.—The planing or paring device for shaving off the

surface of a cylinder is indicated by No. 20 in Fig. 120, and, as will be seen by reference to it, is attached to it, is attached to the back of the arm. It is adjusted by means of the knife screw (No. 20, Fig. 120).

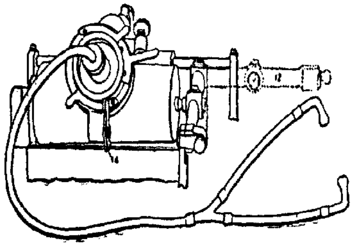


FIG. 123.

When a cylinder is to be shaved the arm should be carried to the centre of the cylinder, and the lift lever, 14, lowered—the diaphragm arm, 16, being set as for reproducing (up), or, for safety, the diaphragm may be entirely removed by releasing the clamps, 38.

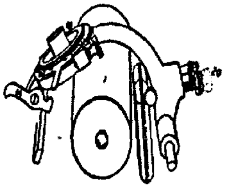


FIG. 124.

Turn the knife screw, 20, which will bring the cutting edge against the cylinder, then raise the lift lever, 14, slide the arm to the extreme left as far as it will go, again lower the lift lever, 14, and start machine.

The knife should always be allowed to pass over the entire length of the surface of a cylinder, otherwise there will remain a portion of the wax thicker than the rest.

After very little practice the eye and ear of the operator will become accustomed to the sound and appearance of a proper cut, and readily detect anything wrong.

The thinnest possible shaving will leave the smoothest surface and waste the least wax. Shave several times, if necessary, in preference to a single deep cut.

Never attempt to set knife whilst machine is in motion.

The best results are obtained by shaving at the highest possible speed, screwing down the speed adjusting screw, 21.

When the old record is completely removed from the cylinder, always see that the knife screw, 20, is turned back again, so as to disengage the cutting edge from the surface.

The fine wax parings dropping from the cylinder while being planed are collected by the chip box, and thus kept from accumulating upon the cylinder surface and forming an obstruction. The chip box should be emptied of these shavings when it is full. As a rule this box holds the parings of two surfaces.

The spring motor of the machine should be wound every now and again, or when required, by inserting the crank and turning handle away from you.

Handling Cylinders.—The wax cylinder, which is somewhat brittle, should be handled gently at first, until the operator becomes practised.

Thrust the first and second fingers of the right hand into the thick end of the cylinder and hold fast by spreading the fingers apart as Fig. 125. Although touching the surface will not destroy the record, there is at all times a certain amount of moisture in the skin, which will leave a mark upon the wax, and will, in the end, make a record sound harsh and scratchy.

Cylinders should be kept in the boxes made for the purpose, which prevent cylinders from coming in contact with each other.

Regulation of Speed.—In order to obtain the greatest amount of record-

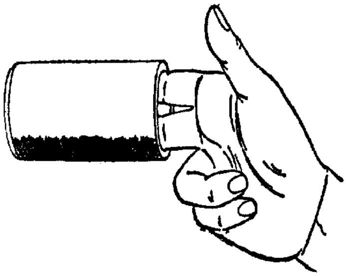


FIG. 125.

ing surface turn the speed adjusting screw (No. 21, Fig. 120) until the cylinder revolves at a very low rate of speed.

The turning of this screw and the consequent lowering and raising of the

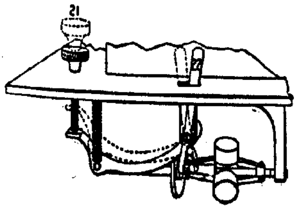


FIG. 126.

speed, results in the lowering or raising of the tone or key of a musical or spoken record. It therefore becomes quite important, in order to obtain a correct reproduction of such a record, that the speed at which it is reproduced should be exactly the same as that at which it was recorded, otherwise it is not an exact reproduction in every respect.

General Instructions, Oil only where directed.—In smearing oil upon any other part you simply set a trap for dust.

To start machine, throw starting lever, 22, Fig.120, to the left. To stop it, throw starting lever to the right.

The speed is regulated by turning the speed adjusting screw, 21, which comes through the top plate at the left of the starting lever.

The sapphire recording and reproducing points should be kept free from dust and wax scales by brushing, or they may be touched with a little benzine on the finger tip.

When the machine is used indiscriminately for both recording and reproducing, do not leave the diaphragm arm, 14, down except whilst recording.

Never attempt to slide the arm from side to side without either raising it or lifting the lift lever, 14, as you are liable to damage the thread of screw at the back of the machine.

Use the camel hair brush to remove chips and dust from cylinders. Do not attempt to blow them off.

Do not leave a cylinder upon the mandrel of machine for any length of time when the machine is not in use.

Do not use the camel hair brush for cleaning the machine; a duster or piece of chamois leather is preferable.

The speed of the main shaft for dictating should not be less than 50 or 60 revolutions per minute, at which speed it will take about eight minutes to cover the entire surface.

Instructions in Brief, to Record.—Drop diaphragm arm, 16, press down lift lever, 14, connect speaking tube,

throw starting lever, 22, to left to start machine; then talk.

To Reproduce.—Take off speaking tube, clear cylinder of all dust, clean points, press diaphragm arm, 16, up. If not very distinct adjust by turning adjusting screw, 15, at the same time pressing diaphragm arm against it. Connect listening tube. Start machine.

To Regulate Speed.—If voice sounds harsh and nasal, turn speed adjusting screw, 15, to the right. If voice sounds too deep and guttural, turn the same screw to the left until the voice appears natural and distinct.

To Shave.—Machine stopped. Slide arm to cylinder centre, drop lift lever, 14, turn knife screw, 20, until knife rests gently against cylinder, at the same time holding arm down with the other hand. Raise lift lever, 14, slide arm as far to left as possible, start machine and allow it to run at its highest speed by screwing down speed screw, 21. When shaved, unscrew knife screw.

Phonograph Record Cylinders.—The master, and also the actual or working records, are shaped as shown in Fig. 127. They are—for the majority of the Edison phonograph—about $4\frac{1}{4}$ in. long and $2\frac{3}{16}$ in. diameter. The bore is taper $\frac{1}{8}$ in. to the foot, to suit the phonograph mandrel, and a number of recesses are formed, as shown, leaving bearing rings or surfaces $\frac{1}{16}$ in. wide. The master blanks are moulded from a white wax preparation. The inside is finished and the outside then turned a few thousandths of an inch taper, the finished cylinders being as smooth as glass, and having the appearance of polished ivory. They are turned, or shaved, in small phonographs mounted on a work-bench, and belted from shafts at the back of the bench. The horns are, of course, removed from the machines, and provision is made for blowing the chips from the work. The cutting-tool operating at the back of each machine is adjusted by means of a screw with a micrometer dial. The work naturally is rotated at a high speed.

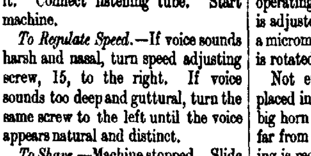


FIG. 127.

Not every blank cylinder that is placed in the phonograph behind the big horn comes out a perfect master; far from it. More or less experimenting is required to find for the case in hand the best suited recorder—that is, the sensitive diaphragm with its holder and sapphire cutting point. And then great attention has to be paid to the proper bringing out of the different musical instruments or different voices. The master records as they are made are thoroughly tested both by musical and mechanical inspectors, to detect any errors or imperfections in the quality of the music reproduced, or in the workmanship of the record. With the master running in the phonograph the trained ears of the specialists enable them to detect the most minute imperfections. As a result, many masters which to most people would appear to be all that could be desired are rejected. Such masters as satisfy all requirements under this inspection are tested again later on to make doubly sure that they are satisfactory from a musical point of view. An examination under a powerful microscope is then made to determine if the wax surface of the cylinder is satisfactory in all particulars. Then comes the making of the mould from the master record.

The first operation in the construction of the mould is the plating of the surface of the wax master. This to the average man would seem a difficult proposition. Fig. 128 gives an idea of

the apparatus invented by Mr. Edison and employed in accomplishing this seemingly impossible task. The wax cylinder is shown at *a* in this engraving, and at *b* is a head over which the cylinder is slipped, and which acts as a support for the latter, it being placed as shown on the conical-ended post *c*. At the top of *b* is secured an armature *d*, and over armature cylinder and support is placed the glass *e*, this resting on a ground glass base *f*. By means of the pipe *g*, connected to a vacuum pump, the air is exhausted from the glass jar, the plating being performed in a vacuum. At *h h* are two glass uprights, insulated from the base by hard rubber bushings *i i*, and carrying conductors *j j*, around which the upper ends of the glass supports are sealed. The conductors are hooked at the top, and on these hooks are suspended two strips of gold leaf, *k k*. The magnet *l* is arranged to be revolved by means of the pulley shown, and armature *d* and the wax cylinder turn with it. An arc being established between the electrodes suspended on the conductors, the gold is vaporised and—as the wax record rotates in the vacuum—is deposited in an infinitesimally thin coating upon the surface of the cylinder.

The master record, having now received its plating of gold, is electro-copper plated, about four days being required to secure the desired thickness of copper—nearly $\frac{1}{16}$ in. This copper shell, with the wax still within it, is then turned off smooth and straight and fitted into a brass shell, which forms really the body of the mould. A section through the mould would now appear something like Fig. 129, *m* being the master, *n* the copper shell (between which and the wax surface is the minutely thin coating of gold), and *o* the brass shell in which is fitted the copper sleeve. The wax is removed from the mould by placing the latter for a few moments in a temperature slightly lower than that of the workroom, the contraction of the wax releasing it from the metal.

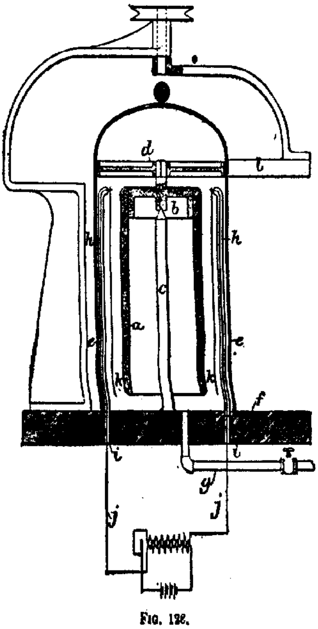


FIG. 128.

The inside of the mould, which is now gold-lined, is thoroughly cleaned by washing with benzine, and the mould is ready for business.

For holding the wax preparation from which the records are formed, a number of long tanks, subdivided into nearly square compartments and heated by gas, are provided. The melted wax in these tanks is dark brown in colour—in fact, nearly black. In moulding the record the mould is lowered into

the hot wax by means of an arrangement shown roughly in Fig. 130. In this sketch *p* is the mould, *q* a cap placed over the top of the latter, and *r* a can in which the mould is placed and held, as indicated, in a vertical

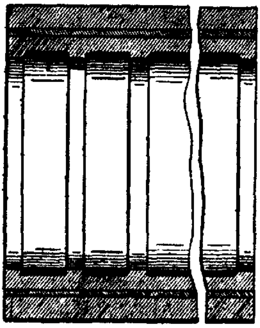


FIG. 129.

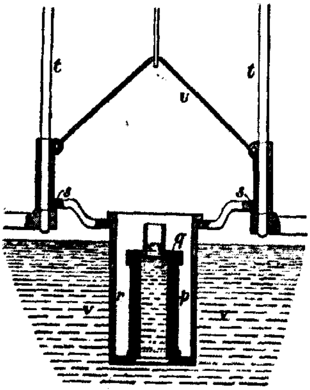


FIG. 130.

position. The can is carried in a frame *s*, which may be moved up and down on uprights *t* by means of the wire bail *u*. The can is lowered into the tank until the top of the mould is below the surface of the wax *v*, the latter entering the mould through the large opening in the bottom of the can. The wax as it passes up into the mould solidifies on coming into contact with the metal and a hollow cylinder of wax is thus formed, the thickness of the cylinder wall depending of course upon the length of time the mould is immersed, and also upon the temperature of the liquid. After remaining in the wax for a minute or so the can is lifted, the cap taken off and the mould removed. The wax adhering to the bottom of the latter is removed by a knife and the mould is then slipped into a special chuck in a machine of the monitor type. Inside shaving tools held in the turret of this machine are then run into the wax cylinder to finish the bore. These tools are made of steel tubing cut away to the centre for a length sufficient to reach through the cylinder and ground to a sharp edge. The tools are somewhat smaller than the rough hole left in the work, and after being run in to the right distance they are brought over against the wax wall by a lever which serves to move the turret laterally on its carriage. Three tools are required to finish the bore; the first roughs out a plain taper hole; the second (which is notched at the edge) cuts the half-dozen grooves around the inside of the cylinder; the third, or finishing tool, brings the narrow bearing surfaces left to the correct taper. These shaving tools operate very rapidly as the work is rotated at a very high speed, the material, of course, being a little softer than anything the average screw machine operator has ever had anything to do with.

When the work is removed from the machine the wax contracts sufficiently in a moment to admit of the

record being removed from the mould. And as fast as the records are finished inside, they are placed on cast-iron shells, or hollow plugs, to prevent their being injured or becoming distorted in further cooling. They are next slipped, one at a time, on a taper arbor held in a machine spindle which is constantly in rotation, and the ends are here finished. After this operation each record is carefully inspected to see if it runs true, and if it is free from flaws of all kinds. Passing this inspection, the record is packed in cotton, slipped into a cylindrical pasteboard box, and packed ready for shipment.

The moulding of these records is without doubt, one of the most delicate, accurate, and interesting operations ever performed in a shop. Just consider for a moment the shallowness of the indentations in the surface of the master record; the gold plating of the wax surface—indentations and all; the preservation in the mould of each and every tiny swell corresponding to its hollow in the master; the accurate reproduction upon an endless number of records of every indentation in the surface of the original wax cylinder. The deepest of the impressions in the master are something less than one-thousandth of an inch; the shallowest are much less than this. The surface of the cylinder presents a wavy appearance, not unlike that of a chattering lathe job, so besprinkled is it with these tiny impressions. And yet all the circumferential grooves traced in the wax by the recording sapphire, and every shallow indentation—no matter how insignificant it may appear—are faithfully reproduced in the surface of the moulded record. With this process a much harder preparation can be used and a more durable record made than was possible under the old method of cutting each cylinder, and, besides, there is practically no wear upon the mould and the thousandth record moulded in it is as clear and sharp, and will reproduce the vibrations originally received by the master record as well as the first one cast.

A sectional view of the recording device used is given in Fig. 131, *a* being the diaphragm of glass or mica

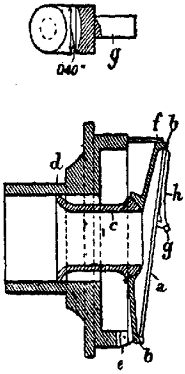


FIG. 131.

about 0·005 in. thick and $1\frac{3}{16}$ in. in diameter; *b* the metal rim in which the diaphragm is held by means of a ring of wax, a thin rubber ring being placed, as shown, under the disc; *c* a tube with spherical end matching a seat formed in the hub of *b*; *d* the body of the device bored to receive *c* and provided at the back with a neck to receive the tube at the end of the phonograph horn. The part *b* is hinged at *e*, and at *f* is a stop-pin limiting the downward movement of the diaphragm rim or weight. The recording point is shown at *g*; the holder *h* for the latter is cemented at the inner end to the diaphragm, and at the outer end is attached to the rim *b*. The enlarged view at the top shows the sapphire point *g* more clearly. It has a body about 0·04 in. diameter cupped at the end, as indicated, to form a keen cutting edge, and is reduced at the back to form a shank to fit a hole drilled in holder *h*. A good idea of the appearance—under a powerful microscope—of the surface of a record operated

upon by this recorder is given in Fig. 118. The centre lines of these rows of indentations are actually 0·01 in. apart, as the lead-screw rotating with the record arbor and feeding the recorder along the wax cylinder is cut 100 threads to the inch. The line traced on the record is therefore a thread of 0·01 in. pitch.

Some very curious results are produced in the wax by the vibrating diaphragm and recorder, the string of nearly round impressions shown to the right in this engraving illustrating the effect produced by a single xylophone note.

A sectional view of the reproducer is shown in Fig. 132. Here *i* is the diaphragm built up of three discs of

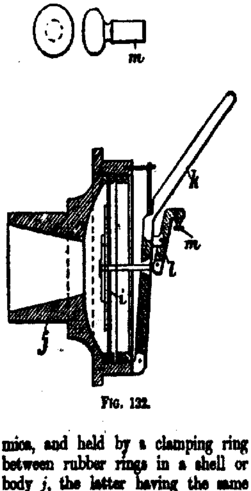


FIG. 132.

mica, and held by a clamping ring between rubber rings in a shell or body *j*, the latter having the same general outline as the body of the recorder. At *k* is a hinged weight limited in its outward and downward movement by a stop-pin, and provided with a lug in which arm *l* carrying reproducer point *m* is pivoted. This arm is connected by a link with the diaphragm, and causes the latter to vibrate as the reproducer follows the path formed by the recorder, the sound waves originally recorded being now reproduced. The sapphire *m* is shown enlarged above the section, and it will be noticed that the end is button-shaped, this form following readily the deepest and shortest indentation in the record. These reproducing points, like those used in recording, are all made at the workshops, a large number of bench tools being used on this work alone. ('American Machinist.')

Phonograph Record Making. The first step towards making a record is the turning (or "shaving," as the phonograph people term it) of the blank, either to true it or to remove the old record from its surface, or both. A special machine is used for this at the laboratory, running at a high-speed, an air-blast being provided to remove the chips as fast as formed. The lack of these two—the high-speed and the air-blast—is the principal obstacle to shaving blanks at home, as the highest speed obtainable on the regular machines is comparatively slow, and the absence of an air-blast allows the chips, warmed by the cutting action, to weld themselves to the finished surface of the blank. Especially is this the case in warm weather when the wax is quite soft. Now both these obstacles can be quite easily overcome. The first by throwing off the phonograph belt and belting to the flywheel of a sewing machine, and the second by using a bicycle pump with some receptacle, as a tin can, for instance, as a receiver to steady the blast. Then, if in warm weather the work is done in the cellar, there is no reason why a beautifully smooth blank cannot be made. The blank must be so smooth that when running it under the reproducer practically no sound will be heard in the horn. It must not be inferred from the fact that the recorder cuts its own grooves, and therefore none of the original blank surface is utilised for reproduction, that it is not necessary for the blank to be smooth. On the contrary, it is impossible to produce a good record on

a "scratchy" blank, as the motion of the recorder jewel is affected by the roughness of the surface.

Having produced a good blank, there would be little difficulty in making a good record of almost any sound, if the wax offered no resistance to the recording cutter, and if the parts to be vibrated possessed no inertia. These two "if's" reduce the usefulness of the phonograph probably more than all other elements combined. The resistance of the wax to the progress of the cutting jewel, always acting to force it away from its cut, makes an outward motion much easier than the inward, and this, aided by the fact that as the cutter enters the wax deeper its length of cutting edge increases, helps to distort the undulations considerably. The inertia of the diaphragm, cross-head, link, arm, and jewel, both in the recorder and in the reproducer, also does much to distort the sound-waves, as is evidenced by the fact that the human voice in many instances cannot be recognised when reproduced, the peculiar qualities giving each voise its individuality being destroyed. The female voice is not so easily reproduced as the male, and among the latter the bass voices lose the least of their individualities because the undulations produced by these in the wax are long as compared with their depth, and their sides being consequently less steep, both the recording and reproducing jewels can follow them more easily. The high amplitude of most female voices, especially in the higher notes, also frequently produces blasty notes by throwing the recording jewel completely out of its cut at the crest of each undulation.

I do not expect any of us will stumble on to a substance that will offer no resistance to a cutting tool and yet produce a permanent record, nor need we look for a substance to paint the vibrating parts with to destroy their inertia; but we can sometimes get on the other side of things by going around them; that has been done before.

Possibly there will be a time when sound will be photographed, and machines then used with means of engraving undulations on a blank exactly representing the sound-waves. ('American Machinist.')

Edison's New Phonograph.—Phonograph diaphragms are usually placed under strain by the compensating weight employed to cause the stylus to press upon the wax and at the same time to accommodate any eccentricities in the blank. These strains destroy much of the sensitiveness of the diaphragm. Mr. Edison, therefore, employs a counteracting spring co-operating with the diaphragm. This spring counteracts the normal strainr to which the diaphragm may be subjected, and which may be due either to the employment of the usual compensating weight or to the direct engagement of the recording device with the record. Fig. 133 represents a partial

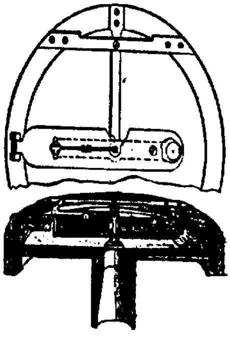


FIG. 133.

recorder sectional view through a phonograph employing a compensating weight and a bottom view of the improved recorder. The spring is connected at one end with the weight and at the other end by a link with the working end of the lever-carrying stylus. ('Scientific American.')

A Toy Phonograph.—The very simple apparatus illustrated in Fig.

134 is a speaking phonograph that can be made and sold for 6*d*., or even less, and yet leave a profit to the manufacturer. It is the invention of Lambrigot, an inspector of telegraphs at Albi in the department of Tarn, in the south

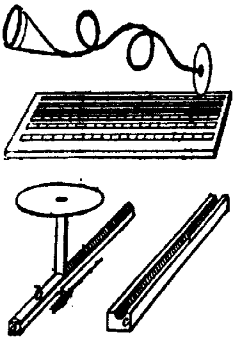


FIG. 134.

of France. The whole apparatus consists, first of a hollow cone of pasteboard about 1½ in. in diameter, whose apex is connected to the centre of a similar sized pasteboard disc by means of a leaden wire about 16 in. long; and second of a small board or tablet, on which is fixed 1, or a larger number of short lengths of leaden wire, each of which bears upon its upper surface a phonographic embossed record corresponding to a certain word or sentence, by which it was originally produced by a process to be described further on.

To those who are familiar with the construction of the phonograph in the form in which it was first shown in this country, it would appear necessary, in order to reproduce the sounds recorded on the tablet, for the edge of the disc to be held in an annular frame so as to convert it into a diaphragm, and for its centre to be thrown into vibration by means of a point or style projecting from it and drawn over the undulatory surface of the record. But the method of using the apparatus is far simpler than that; all that is necessary is to hold the paper cone against the ear with one hand and with the other to take hold of the cardboard disc, drawing its edge along the record with a steady scraping motion, and the mechanical vibrations thus set up in the disc being communicated by the wire to the conical earpiece which serves as a resonator and concentrator, produce in the organs of hearing, the sensation of the articulate sound by which the markings on the leaden record were originally produced. We should have thought that a stout thread or a lighter wire would have formed a more efficient as well as a cheaper connection for the purpose than the leaden wire, but we are informed that Lambrigot has found the lead to answer the purpose better than anything else; it does not require to be kept stretched between the cone and the disc, and being of a very inelastic nature, it does not spring about and produce disturbing sounds by clashing against itself or against neighbouring objects. Again, it would naturally be expected that the earpiece would be more perfectly adapted to its purpose if it were in the form of that used in the ordinary thread telephone; that is to say, if it consisted of a cylindrical cardboard box closed at one end with a stretched paper diaphragm, to the centre of which the connecting wire was attached; but simple as it is, this would undoubtedly be a more complex form of construction than the cardboard cones, and would be far more liable to be destroyed by the weight of the connecting wire. The employment of cardboard as the material of which the principal parts of the apparatus are constructed, is, in the case of the cone, for cheapness, and in that of the disc, partly for cheapness, but chiefly to protect the markings on the leaden record from being destroyed as they soon would be if a harder material than card were employed.

The most interesting point connected with this very simple apparatus is the method by which the leaden

records are produced, which is as follows: The upper surface of a rectangular prism of glass, or other hard and rigid material, is thickly coated with stearine wax, which is then scraped into a convex form, as shown in the diagram, in which *a* represents the glass bar and *b* the convex coating of stearine. This bar is then fixed into a simple phonographic instrument, which, by means of a screw or other mechanical contrivance, traverses it at a suitable speed below a diaphragm. This diaphragm is rigidly held around its circumference by an annular framework (not shown in the diagram), and is in every respect exactly similar to the diaphragm of an ordinary phonograph. To the centre of this diaphragm is attached a thin flat plate, whose lower end is cut out to a concave curve, to fit the convex surface of the stearine *b*. When all is properly adjusted, and the temperature is so arranged as to give to the stearine surface the proper degree of hardness to ensure the best results, the handle of the instrument is turned, and at the same time words are spoken against the diaphragm, which immediately set up in it vibrations, which are communicated to the plate or style. While this is moving up and down following the vibrations of the diaphragm caused by the voice, the stearine coating of the bar *a b* is steadily drawn in the direction of the arrow below the vibrating bar, receiving from it a phonogram similar to that produced on the wax of an ordinary phonograph.

The stearine bar is then coated with a fine surface of graphite, so as to give to it an electrically conducting surface, and it is then electro-plated with copper by the ordinary process. Out of the copper coating so formed the stearine is removed, and a rigid backing of lead or other metal having been run over the outside convex surface of the copper, a firm copper-lined matrix or mould is formed, the whole presenting the appearance shown, and consisting of a rectangular block having along the middle of one of its faces a semi-cylindrical groove *c* of copper, which bears upon its surface certain raised striations corresponding to the depressions which were made by the diaphragm on the surface of the stearine. Into this groove is laid a piece of lead wire about 3 or 4 mm. in diameter, and the two being put into a press and squeezed together, the surface of the lead wire receives a permanent impression which is an exact reproduction of the original impression made upon the stearine bar. From one copper matrix a very large number of lead impressions may be made, and we are told that the whole process can be gone through, and lead wires, each containing the record of a short sentence, can be made and sold with a profit for ½*d*. each.

It is an interesting fact that if a small stick of wood, such as the stem of a common match, be substituted for the disc, and its end be drawn along the copper groove of one of the matrix moulds, articulate speech is communicated equally well to the ear-piece, although the motion of the point is the reverse of that of the disc; and this bears a very close analogy to the fact that in the ordinary Bell telephone a message is transmitted with equal distinctness, whether the poles of the receiving instrument be reversed or not. ('Eng. Mech.')

A SIMPLE PHOTOGRAPHIC ROCKING-TABLE.

FIG. 135 which illustrates this shows an ordinary iron or wooden bracket fixed on a wall or any upright, and the "table" on this can be of any required size, according to the size or number of trays it is to carry. When the bracket is secured, the only fixing the table requires is two screws through into the bracket, and an important detail is that these screws must not be driven quite home, but be left so that the table will rock. Let the screws come in a line which is the exact centre of the table from front to back, otherwise the table will not balance properly. For a single tray the table may be as small

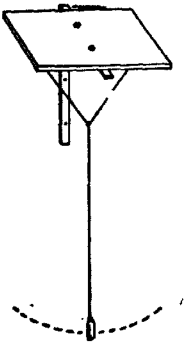


FIG. 135.

as 12 in. by 8 in. On the underside at each end (or very near the end) screw in a hook or eye, as centrally and at equal distance from the middle screws as possible, and to these attach wires as shown, joining one wire which drops down 3 ft. or 4 ft. with a weight on the end as shown. When this pendulum weight is set going, it will keep the table rocking steadily and evenly for several minutes, and only requires a touch when its motion is becoming insufficient.

A SIMPLE PHOTOMETER.

WITH the simple instrument about to be described it is an easy matter to determine with a considerable degree of accuracy, the illumination, or candle power, of burners of different size burning any particular gas. The method is illustrated in Fig. 136, which shows a simple photometer for measuring illumination.

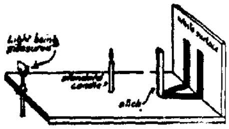


FIG. 136.

A candle power of light is the amount of light produced by a sperm candle, which burns 120 gr. per hour.

A candle of this kind is used as the standard in the following determination. Sperm candles $8\frac{1}{4}$ in. in length six to the pound, will answer the requirement. The apparatus consists of a board 3 or 4 feet long at one end of which a sheet of white paper or card may be fixed in an upright position.

In front of this paper and possibly three in. from it, set up a stick, this being used for casting a shadow on the paper. Set the standard candle about 2 feet from the paper. The apparatus is now ready to use. Move the apparatus away from the light which is to be measured to such a distance that the standard and the light to be tested each cast a shadow on the paper of equal intensity as judged by the eye. These shadows should be brought close together so that the comparison may be as definite as possible.

When this result is reached, measure the distance of the light that is being measured from the paper in feet and fractions of a foot, and divide this amount by the distance in feet and fractions of a foot of the candle from

the paper. The candle powers of two lights casting equal shadows on the same surface is in the ratio of the squares of their distances from that surface. Therefore, to obtain the candle power of the light being tested, square the result obtained by dividing the two distances. Thus if the gas light in the illustration is 12 ft. from the paper when its shadow is of the same intensity as that of the candle at two ft. from it, its candle power will be 36; thus $(12 \div 2)^2 = 36$, or $12 \div 2 = 6$, which squared $(6 \times 6) = 36$.

PICTURE FRAMING.

(*See also* GILDING, POLISHING, STAINING, ETC.)

IN dealing with the subject of picture-frames, it may be assumed that the moulding, if of plain wood, can be made in the workshop, or purchased; or, if having an ornamental design in composition, it is obtained from a dealer in these goods. Recipes for this special picture-moulding composition are given, as it is often necessary to use some either with new frames or repairs. In good quality gilt frames, it is customary to cover the four joints with a label, or slip, of composition, made into the form of a leaf or other ornamental design, this added ornament being gilded over by the maker of the frame.

For simple frames with mitred corners, the tools required are a fine back-saw; a mitre-cut or mitre-box, Fig. 137; a mitre-shoot, as Fig. 138, and a trying-plane. Besides

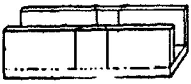


FIG. 137.

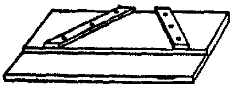


FIG. 138.

these, a glue-pot and a hammer are the chief remaining things needed. The purpose of the mitre-box is to enable the moulding to be sawn to a fairly perfect angle of 45°, the moulding being laid in and held along one side of the box, while the saw is worked through one of the pairs of cuts shown; but the cut made by this means, though it may be as near accurate as possible, is not sufficiently smooth and good for jointing. It has to go to the mitre-shoot to be finished. In cutting in

the mitre-box, if accurate dimensions are required, allowance must be made for the thickness of the saw-cut, also for the shavings taken off by the plane on the mitre-shoot. It is also important to remember this when making small frames, as a difference in length of $\frac{1}{16}$ in. in the side or end pieces will make one of the joints come untrue although it may be finished to a precise angle.

When the pieces come from being sawn in the mitre-box, they are laid, face up, against one of the angle guides of the shoot, and the plane, laid on its side, is run along as Fig. 139 shows.

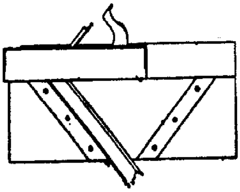


FIG. 139.

As simple as it looks, this requires practice before a perfectly true mitre can be made, but with practice it can soon be accomplished.

Having made the four pieces equal in size and true, the jointing up is usually done in a "cramp," though this is not always the case in practised hands. Picture-frame makers, especially with cheap goods, glue the ends, then nail them while on the bench, and this ends the matter, but the amateur will not find it easy to do this, nor do makers adopt this plan with good work. If accurate joints are to be made, which in plain wood, say oak, will bear close inspection, the cramp is necessary.

Perhaps the first thing to be mentioned is the glue. Any fair quality glue will do, but it must be properly made. Newly-made glue is always best, but if using a glue-pot frequently it may be re-heated day by day, although each time the glue runs low the pot should be cleaned out before new is added. If glue is allowed to get a mould, or thick dust on it, it should be thrown away. It should be as clean and clear as golden syrup and a little thinner. Never use thick glue with the idea that it holds better. It makes thick and bad joints, and if two surfaces to be glued together are true and smooth, they only require a thin film of glue between them. The glue must not, of course, be watery, as it should not soak away in the wood. This means that the glue has no sticking power, and what is worse, it is like wetting the surfaces with water, causing them to swell and become untrue. Always glue both surfaces that are to come together. Do not glue one and press this to a dry one, thinking there is enough glue for both. The glue should also be slightly worked on the surfaces that it may go a little way into the pores and so get a good hold. These details apply to all glueing processes and are essential to good work.

The cramps for this work take many forms. Fig. 140 is one of Churchill's, operated by a cam lever attached to a

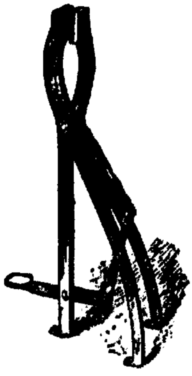


FIG. 140.

treadle, thus leaving both hands of the workman free. It will be seen that the purpose of the cramp is to hold the joint while it is nailed.

The mitre-shoot, Fig. 138, can be made a cramp if desired, a triangular piece being screwed on, as Fig. 141;

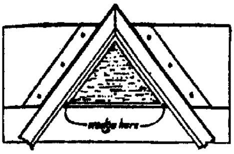


FIG. 141.

long and slightly taper wedges being inserted, where shown, when the two pieces of moulding are in place.

Fig. 142 shows another simple cramp which needs no description.

FIG. 142.

It should have been mentioned earlier, perhaps, that not all frames have nailed joints; or, if nailing is done, it may be after the glue is set. The writer never uses nails, partly because of their bad appearance and partly by it not being easy to get a true-nailed joint before the glue is set. To secure the glueing he prefers either before the glueing, or afterwards when it is dry, to make a downward saw-cut at the angle, as Fig. 143, and glue a

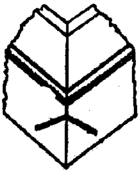


FIG. 143.

slip of hard wood in this. It certainly makes the most workmanlike and neat job with plain wood frames.

A simple cramp can be made with string and wood blocks, as Figs. 144 and 145. After glueing the ends of the moulding, put them together, flat on the bench, then wind a cord round

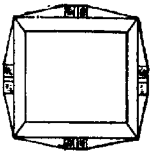


FIG. 144.

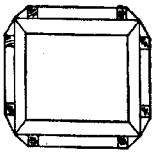


FIG. 145.

the outside edge three times and tie it. Then insert eight pieces of wood, ¾ in. or 1 in. square, between the cord and the frame, as Fig. 144, adjust all the joints true and flat, then press the wood blocks into positions shown at Fig. 145. Nailing is done after the glue is dry, holes being bored to receive the nails and to lessen the jar of nailing.

A probable adjunct to the frame is a gilt "slip." This is an inner frame fitting into the rebate of the true frame. These are made of gilt flat moulding (without a rebate as a rule), first cut in the mitre-box, then shot on the mitre-shoot, finally glued up and nailed. In glueing and nailing these it is customary to put one piece in a vice (the jaws being covered with paper or leather) the other piece being held in position and nailed, as Fig. 146.

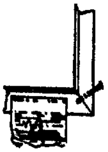


FIG. 146.

There now remains the picture to

be put into the frame, and in this more faulty work is done than in any detail of the work. The work that is neglected is the making the frame dust-tight. Many old engravings, now having a high value, are more or less spoiled by dust, also by not being air-tight, which might have been averted with ease. Even now water-colours of high price are not protected from dust as they should be. The pasting of paper on the back of the frame and backboard will make the back air- and dust-tight, but the joint between the glass and the frame at the front is neglected. It is here that the damage is done, for crevices must exist and these lead to the front of the picture. The back of the picture should be protected, of course, but the front is more important.

Fig. 147 shows the simple means of doing this. The picture itself is omitted, but it is understood to come between the backboard and the glass. The protection is simply a strip of paper pasted, or preferably glued with thin glue or paste-glue, partly on the glass and partly on the wall of the rebate, as shown by thick black line. This should be tough air-proof paper, like rolled manilla paper.

FIG. 147.

In every case the framed picture should be made air- and dust-tight at back. With small pictures this is effected by pasting a sheet of paper over the whole back, but with large pictures the paper is only pasted over the joints between backboard and frame and the joints or cracks in the backboard itself. When arranging to cover the whole of the back of a picture of a square foot in size or larger, the paper must stretch tight and not be in creases or wrinkles when finished. This is easily done by applying water to the paper before it is pasted or glued on, which causes it to shrink on drying. This shrinkage is so great a force that care must be used in the wetting. The writer once wholly covered the back of a picture only 1 ft. square, wetting the whole of the paper before it was glued on, the glueing being at the edges only. The shrinkage pulled all the joints in the frame open, and since then it has been found better to limit the wetting to two or three stripes made with a brush or sponge. The shrinkage of these marks will be found sufficient to make the back paper as taut as a drum-head.

Composition for Picture-Frames.—(*a*) This composition is a kind of putty used to make ornamental detail on a plain wood backing or base, but in the hands of the amateur is used more for forming leaves and flowers, to cover joints or to enrich a frame to his taste. It is also used in repairing damaged gilt and composition frames. It can be gilt or painted over and, if well made, is tough and lasting.

For small purposes it will be found sufficient if some thin hot glue is made, and whiting is sifted into this and worked until of the consistence (and appearance) of putty. This can be modelled into any form, oil being used on the fingers or any tool used. If the mixture gets hard, steam will soften it.

The proper recipe for the composition is 1 lb. glue melted (by heat) in water sufficient to make a thin glue. Melt ½ lb. of pale resin in ½ pint raw linseed-oil. Pour the whole together and boil for ½ hour, stirring and watching that it does not boil over. Now mix in sifted whiting and knead the mass to a dough. This should be kept damp, but if it hardens it can be made plastic by steaming it.

In making composition ornaments in any numbers moulds are used, generally of box-wood, though metal may be used. These are brushed over with oil before the composition is pressed in, the pressing being done in a screw press, a wet board being put over the composition in the mould so that the ornament can be withdrawn

stuck to the board. The ornament is not allowed to harden in the mould; it is simply pressed in, then withdrawn, and removed from the board by a large thin knife. It is then put aside to harden. A good pressure should be employed, on the composition in the mould, that a solid well defined object may result.

Should it be required to copy an ornament on a frame, with a view to producing one like it for repair, the following plan may be adopted. First give a coat of wax or vaseline to the carving or ornament to be copied, then after making some kind of surround to it (with composition or putty, for instance) pour liquid plaster-of-Paris over the ornament and let it set. When set (in about 20 minutes) it can be lifted off, the wax preventing it adhering, and a mould is thus formed into which composition can be pressed. The mould should first be rubbed over with wax or vaseline and the pressing must be done gently with so fragile a mould. If the carving or ornament to be copied is slightly undercut, then instead of plaster-of-Paris some picture-frame composition can be used, this being pressed into all the parts and then removed before it is quite hard, while it has some flexibility. In this case the copy must be made by pouring liquid plaster or cement into the composition mould, then, when it has set, soften the composition with steam heat and pull it off. Wax or vaseline must be used between the mould and the ornament, in every case.

(*b*) Mixing.—The principal ingredients are glue, water, linseed-oil, rosin, and whiting, which are combined in such proportions as to make a mixture soft enough for working, while, at the same time, it should be so tough as not to crack, and should harden in a few hours if the ornament be thin, or in a day or two if it be more massive. The state in which it is used by the ornament maker is that of a stiff dough; and the making of it resembles the process by which the baker makes his dough. The proper amount of glue is steeped in water, which is heated to dissolve the glue; while the oil and rosin are melted in a separate vessel, and then poured into the vessel containing the melted glue. The whiting is pounded, and placed in a tub or pan—being previously warmed if the weather be damp and cold—and the hot melted glue, oil, and rosin are poured upon the whiting, and then well mixed up with it, and kneaded, rolled, and beaten until it becomes a smooth, tough, elastic kind of dough or putty. It may then either be used at once, or may be laid aside for future use; but, whenever it is used, it must be warmed, either before a fire or by admitting steam to act upon it, because, when cold, it is too hard and stiff for use.

The manner of using this composition is to press it into moulds; the preparation of which is the most important part of the business; it is generally done by men who are not engaged in making the ornaments themselves. The moulds are usually made of boxwood, which, by its smoothness of grain, permits very fine figures to be cut in it, and is very durable. The mould carver has to proceed with his work in an opposite way to the ordinary carver; for he must make depressions or hollows instead of raised projections, and projections instead of hollows. The mould carver makes his mould look, in every part, directly the reverse of what he wishes the ornament to appear.

Making the Moulds.—The block of wood being planed and smoothed, the carver draws on its surface a representation of the object which he wishes to carve, and then proceeds to work out the minute details. The tools used in this carving are exceedingly fine and sharp, some of them not exceeding $\frac{1}{20}$ in. in width. These are, as in common carving, mostly gouges, with various degrees of curvature. The sharpening of them is a matter of great nicety, and in some cases requires files made of very fine wire,

The block of boxwood is moistened with oil during the process of cutting, in order to facilitate the progress of the tool. The cuts are, in the first instance, made perpendicularly from the surface of the wood, and afterwards varied into the necessary directions to produce the pattern. In order to know how to vary the depth of different parts of the mould, the carver must either be guided by the accuracy of his eye and the correctness of his taste, or he must have another mould of the same pattern before him.

Sometimes moulds are made by casting, the material being brass, copper, pewter, lead, or sulphur. A model, representing the object which it is desired to produce, is made of composition or plaster, and is placed on a flat stone, and surrounded by a raised border or edging, so that it lies in a cell or trough. The model is then oiled, and the melted metal or sulphur is poured on it, so as to entirely cover it. When cold, the raised border is broken away, the mould is taken up, and the model is removed from within it. It is then embedded in a wooden case to preserve it from injury, and to fit it for the better reception of the composition. Sometimes brass moulds are made in this way, and afterwards chased; that is, the minuter details of ornament are cut, or rather scratched, by very fine tools. When the mould, whether of wood, metal, or sulphur, is to be employed to cast ornaments, it is brushed over with oil, to prevent the adhesion of the composition. A piece of composition, large enough for the intended purpose, is then taken up in a warm soft state, and pressed into the mould by the hand. A wet board is laid upon the surface of the composition, and the whole is put into a powerful screw-press, by which the composition is pressed into every part of the mould, however deep and minute it may be. The same pressure makes the upper surface of the composition adhere to the wetted board, so that, when it is taken out of the press, the mould may be pulled off the ornament, leaving the latter adhering to the board. When the cast has become a little hardened, it is cut, or rather sliced off, with a broad knife, to the required thickness.

Fixing Composition Ornaments.—The composition ornament, when made, is exceedingly pliant and supple, and may be bent into almost any form without breaking or injuring it; it is this property which makes these ornaments so convenient; as they may be applied to round, flat, or hollow parts with almost equal ease. They are fixed on either with glue, or, if quite soft and warm, with hot water, which, by softening the glue contained in the composition, produces a sufficiently strong cement; and, in a short time, they become firm and hard enough to be handled without injury. In modern work intended to imitate the antique, the manner of laying on the various pieces of ornament requires much care in the workman. If an antique carving, or a drawing from it, is given to the ornament maker to imitate, he must have moulds carved of all the various parts, so that, when united on the frame, the assemblage of composition casts may represent a facsimile of the original. If he wishes to produce work which shall possess a general resemblance to old patterns, but without tying himself down to any individual pattern, he has to depend on his taste and judgment, both in the cutting of moulds and in the disposition of the various pieces of ornament. This composition, being a compact substance, is heavy. In this point carved ornaments have a great superiority over composition; indeed, the heaviness of the latter was one reason which led to the adoption of papier-mâché ornaments. When papier-mâché ornaments are used, they are cast in moulds, resembling those just described. The paper is in the state of a pulp; but there is this difference between the two kinds of ornaments. The pulp is pressed between two moulds, so that the thickness of the ornaments is seldom more than about ' in. at any part; thus the

ornament is of less weight, and there is a saving of material.

Staining Oak Moulding.—(*Also see* the general subject of STAINING.)

Brown.—Mix dry brown umber with liquid ammonia until like thin paint, then dilute with rain water to the desired tint. Vandyke brown will make a darker brown, and, with either, a weak solution of bichromate of potash may take the place of ammonia. Apply freely with a brush, rubbing well in, then wipe off the surplus with a cloth. The potash solution by itself has a darkening effect on oak.

Antique.—Fuming with ammonia (*see* STAINING) is as good a plan as any, but failing this, make a red oil by steeping 2 oz. of alkanet root in ½ pint of raw linseed-oil and wipe over the wood with this. Next rub in a solution of bichromate of potash, ¼ oz. in ½ pint of water, finishing off in the direction of the grain. It will be necessary to repeat the operation one or more times for a dark shade.

Green.—Any aniline colour that will dissolve in vinegar will do for this; or the following mixture will serve: ¼ lb. verdigris, ¼ oz. sap green, ¼ oz. indigo; grind to a fine paste with vinegar. Add about three pints of good malt vinegar, and use as a stain. If desired, the sap green may be omitted, the resulting colour then being more blue in tint. The verdigris and indigo are then dissolved in vinegar which has been brought to the boil. The stain can be applied hot, and as often as the depth of colour required makes necessary.

Bronze Green.—Obtain dry bronze green from a colourman's, and mix in hot vinegar. Apply as many coats as appear requisite.

Ageing Gilt Frames.—To make new gilt work appear old, take a small quantity of aniline brown (soluble in water) and add it to the parchment size solution which is applied to the frame after gilding.

Cleaning and Renovating Gilt Frames.—(*a*) Fly-marks can be cleaned off with soap and water used sparingly on end of finger covered by piece of rag. When all cleared off, rinse with cold water, and dry with chamois leather; next buy 1 lb. (1*d.*) of common size, and 2 penny paint pans. Boil a little of the size in one of the pans with as much water as will just cover it. When boiled, strain through muslin into clean pan, and apply thinly to frames with camel-hair brush (called technically a "dabber," and costing 6*d.* to 1*s.* each). Take care you do not give the frames too much water and "elbow grease." On no account use gold size, as it is used only in regilding, and if put on over the gold would make it dull and sticky.

(*b*) Dissolve a very small quantity of salts of tartar in a wine bottle of water, and with a piece of cottonwool soaked in the liquid dab the frames very gently (no rubbing on any account, or you will take off the gilt), then stand up the frames so that water will drain away from them conveniently, and syringe them with clean water. Care must be taken that the solution is not too strong.

(*c*) If new gold frames are varnished with the best copal varnish, it improves their appearance considerably, and fly-marks can then be washed off carefully with a sponge. The frames also last many times longer. It also improves old frames to varnish them with it.

(*d*) Gilt frames may be cleaned by simply washing them with a small sponge, moistened with hot spirits of wine or oil of turpentine, the sponge only to be sufficiently wet to take off the dirt and fly-marks. They should not afterwards be wiped, but left to dry of themselves.

(*e*) Old ale is a good thing to wash any gilding with, as it acts at once upon the fly-dirt. Apply it with a soft rag; but for the ins and outs of carved work, a brush is necessary; wipe it nearly dry, and do not apply any water. Thus will you leave a thin coat of the glutinous isinglass of the finings on the face of the work, which will prevent the following flies' fæces

from fastening to the frame, as they otherwise would do.

(*f*) Dingy or rusty gilt picture-frames may be improved by simply washing them with a small sponge moistened with spirits of wine or oil of turpentine, the sponge only to be sufficiently wet to take off the dirt and fly-marks. They should not be wiped afterward, but left to dry of themselves.

PIPE BENDING.

Copper Pipe.—(*a*) Copper pipes, unless quite small, should be filled or loaded before bending in order to prevent any kinks or dents during the operation. If the pipe is lacquered, it should be cleaned off before heating and re-lacquered afterwards. To load the pipe, first tie some brown paper round one end and imbed this end in sand. Melt sufficient lead in a ladle, and pour into the tube until full. If a bench is available, cut a hole in this a little larger than the tube then chamfer and round off the edges of the hole. Remove the paper from the tube, put the tube through the hole and pull the tube over the rounded edge of the hole to the extent required. Unless a very short or slight bend is aimed at it will be found necessary to keep working the tube through the hole, little by little, and bending each time. If the throat of the bend is dented, work this out with ball-faced hammer, before the lead is run out. When the bend is complete, heat the tube, and run the lead out. If a number of bends have to be made to one curve, a template should be cut to work to.

(*b*) The usual method of bending copper pipe through a hole in a bench sometimes results in dents being made in the throat of the bend, and the

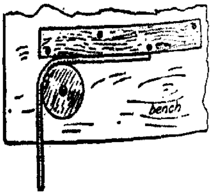


FIG. 148.

following contrivance will obviate this. Take a piece of hard wood, about 20 in. by 3 in. by 2 in. thick, and secure it to the bench, as shown in plan by Fig. 148. Then make a disc of hard

wood of same thickness (2 in.) and secure it to the bench, so that it will revolve, but otherwise be firm. If the operator has any particular sizes of bends to make he can vary the size of the disc to suit. This disc, and the pipe between it and the straight piece of wood, are shown in the illustration.

(*c*) Copper pipe up to $\frac{3}{8}$ in. can usually be bent, unloaded, but for $\frac{1}{2}$ in. up to $\frac{7}{8}$ in. the pipe should be heated prior to bending. When loading with lead it is best to heat the pipe a little before pouring the lead in, and when the lead is in, let it cool of itself, and do not put it in water. The melting out of the lead can be done with a blow-lamp, if desired.

(*d*) After plugging up the end of the pipe it can be filled with melted resin, or, if this is not available, sand can be used, rammed in. If molten lead is not used, the pipe before filling should be softened by heating, as it will then bend better.

(*e*) Sand will do for filling for slight curves, melted pitch for sharper curves. This would be for pipes of moderate size. Lead should be used for loading large pipes.

(*f*) When a copper or brass pipe is loaded with rosin for bending, it may be found that after bending a certain distance the pipe seems to become much stiffer. The apparent stiffening is often due to the hardening or compressing of the material within, and if the pipe is warmed enough to soften or release the rosin, it can then be bent with ease again. Copper pipes have been broken through a neglect of this precaution.

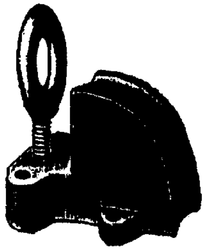


FIG. 149.

Iron Pipe.—(*a*) First mark off where bend is to be made, and open a vice until the pipe will pass freely between jaws without gripping. Then heat pipe carefully between marks a nice bright red; place heated part between jaws of vice, and taking hold of pipe each end, pull towards you; the vice keeps the pipe from bulging; if long pieces, a little help may be needed; nice sweeping bends should always be made where possible. Iron pipe can, with care, be easily bent to gentle curves, if the heat is maintained as even as possible—say, a bright red—and the pipe bent a little at a time. Iron pipe is never loaded or filled for bending.

(*b*) A very useful tool for bending iron pipe up to 2 in. is that illustrated at Fig. 149. This could readily be made of wood for copper and brass tube (or small iron tube) which are bent comparatively cold. It requires to be of metal for pipe that is made red-hot for bending.

There are various forms of pipe-bending appliances on the market, but the preceding are simple and effective.

Lead Pipe.—It is customary to bend this without loading, the plumber relying on drifts and special tools to work out any inequality that may be created. Of late years the bending device, Fig. 150, has been largely employed. It is simply a stiff wire wound spirally—much like a spiral spring—and, needless to say, a separate one of these tools is required for each different size of pipe. For any

FIG. 150.

size pipe below 1 in. it is scarcely necessary, but from 1 in. to 4 in. excellent bends can be made, even of S form. In using these, a plug (supplied with the tool) is first passed through the pipe to clear any irregularities; then, after putting a little oil on the spring, it is slipped into the pipe and the bend at once formed. To remove the tool after the bend is made first *bend back a trifle on each bend*, then, holding on end of the bender, twist it to the right which will cause it to decrease in diameter, and if, while doing this, a gentle pull is given, the tool will come away.

Bending Split Steel Tubing.—Split steel tubing, if not larger than 1 in., can be bent without heating, if it is not of very thick substance. Loading with sand, and bending as described with copper tube, will answer, or a mixture of pitch and sand (the pitch being melted and mixed with the sand) will be better. If molten lead is used for the filling, any curve can be formed, but the lead must only be just soft enough to pour or it will run through the split. The pitch or lead is melted out, after bending, as described with copper tube.

PLANCHETTE.

THE planchette, as ordinarily made, consists of a piece of thin board (about $\frac{3}{16}$ in. thick when finished) cut heart-shaped, as Fig. 151, the size not being

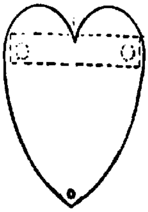


FIG. 151.

important, but usually measuring about 6 in. each way. At the broad part, on what is to be the underside, a pair of small easy-running castors are secured, a cross slip of wood being used to thicken the board at this point for the better holding of the castors. At the point end a hole is made to just take a piece of lead pencil and hold it firmly. Fig. 152 gives these details. In use the

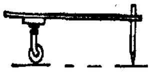


FIG. 152.

planchette is placed on a sheet of white paper spread on some level surface, while the fingers of the operator or operators are placed lightly on the top of the instrument, and answers are given to questions asked. The results, however, are not always satisfactory. In some cases the writing is tolerably clear—whether by accident or design is for the user to consider—but often enough an illegible scrawl is the only outcome. Imagination then often steps in, and the pencil marks are construed into words to fit the question at issue. In order to remove doubt as to the words or letters produced, a specially

prepared board may be used, and those interested in the instrument will do well to adopt this. In this case a fixed pointer can be substituted for the pencil in the planchette. Such a pointer can be a curved piece of wood or of some shape that will admit of its projecting and being easily seen. Fig. 153 shows how a board may be prepared,

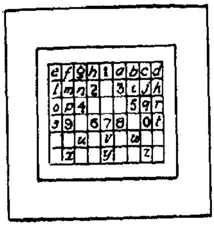


FIG. 154

the illustration being given to show how letters and figures should be put at random. Failing this there must be some suspicion or doubt at the results obtained. A piece of cardboard will do for this, size about 20 in. by 16 in. which, with margin, allows of 2 in. spaces being given to the letters and figures. Some of the spaces should be left blank as shown. If desired, the spaces may be reduced in size and increased in number, in which case short words, or signs having special meanings, may be introduced as well as the letters and numerals. This card may be secured by its corners to a large drawing-board, and when planchette is placed on the surface, one or two inquirers should rest their fingers on the instrument, which will dodge about over the squares and indicate certain letters, words and numbers. If several persons wish to take part in the game (for it should not be considered anything more serious than this), an instrument may be made with several handles. Have a spoke wheel-head made as Fig. 154, with as many handles as desired, and through the centre of this put a stem to rest on the board (Fig. 153). From the side of the stem let a pointer project, and this, when the handles are held tightly, will begin to move and select letters or words to make a reply to the question asked. It is understood that in using planchette a question is formulated for the instrument to answer. If several are using it the one question must be agreed to by all, or it is supposed that the

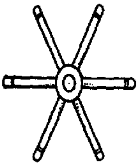


FIG. 153.

"influence" will not act agreeably. By some it is asserted any experimenter "out of sympathy" (belief perhaps) with the instrument or the other experimenters, causes planchette to give confused replies. This makes an excellent excuse for the meaningless jumble that so commonly results in unprofessional hands. In the hands of an experienced manipulator planchette can do amazing things, but though there is less cause for amazement there is greater fun when the inexperienced call in its aid.

PLASTERS AND PLASTERING WORK.

(*See also* WHITEWASHING AND DISTEMPERING.)

THE plaster used for covering the walls of buildings is a mortar composed of lime or cement and sand, mixed in various proportions, generally with a little hair or some such material to give it elasticity. It is laid on by hand with a trowel in several thicknesses of about ⅛ to ½ in. each, and either on the bare masonry wall or on a special screen of lathing made for it, to either of which it adheres by entering into and keying itself in the joints and openings, and by its adhesive quality. With some variations in the materials and mixing, it is used for exterior and interior work and for ceilings. For the purpose of assisting to keep the interior of the rooms of a house dry, it is advantageous to employ lathing, which being detached from the masonry of the walls, forms a lining, distinct in itself, and not liable to the effect of moisture which may be in the walls. It is of the utmost importance, in plasterers' work, that the lime should be most thoroughly slaked, or the consequence will be blisters thrown out upon the work after it is finished. Many plasterers keep their stuffs a considerable period before they are wanted to be used in the building, by which the chance of blistering is much lessened. When a wall is to be plastered, it is called "rendering"; in other cases the first operation, as in ceilings, partitions, etc., is lathing.

Lathing is the nailing of laths to the joists, quarters or battens. The lath is made in 3 or 4 foot lengths, and, according to its thickness, is called single (something less than ¼ in. thick), lath and half, or double. The first is the thinnest and cheapest, the second is about one-third thicker than the single lath, and the double lath is twice the thickness. When the plasterer laths ceilings, both lengths of laths should be used, by which, in nailing, he will have the opportunity of breaking the joints, which will not only help in improving the general key (or plastering insinuated behind the lath, which spreads there beyond the distance that the laths are apart), but will strengthen the ceiling generally. The thinnest laths may be used in partitions, because in a vertical position the strain of the plaster upon them is not so great; but for ceilings the strongest laths should be employed. In lathing, the ends of the laths should not be lapped upon each other where they terminate upon a quarter or batten, which is often done to save a row of nails and the trouble of cutting them, for such a practice leaves only ¼ in. for the thickness of the plaster; and if the laths are very crooked, which is frequently the case, sufficient space will not be left to straighten the plaster.

Laying.—After lathing, the next operation is laying, commonly called plastering. It is the first coat on laths, when the plaster has two coats or set work, and is not scratched with the scratcher, but the surface is roughed by sweeping it with a broom. On brickwork it is also the first coat, and is called rendering. The mere laying or rendering is the most economical sort of plastering, and does for inferior rooms or cottages. What is called pricking up is the first coat of three-coat work upon laths. The material used for it is *Coarse Stuff*, being only the preparation for a more perfect kind of work.

Coarse Stuff is made with chalk-lime prepared as for common mortar, but slaked with a quantity of water, afterwards evaporated, mixed with an equal quantity of clean sharp sand, and cow hair at the rate of 1 lb. of hair to 3 cub. ft. of stuff. After the coat is laid on, it is scored in diagonal directions with a scratcher (the end of a lath), to give it a key or tie for the coat that is to follow it.

Lath laid or *plastered and set* is only two-coat work, as mentioned

under laying, the setting being the gauge or mixture of putty and plaster, or, in common work, of *Fine Stuff*, with which, when very dry, a little sand is used.

Fine Stuff is a mortar made of fine white lime exceedingly well slaked with water or rather formed into a paste in water to make the slaking complete; for some purposes a small quantity of hair is mixed up with it. Fine stuff very carefully prepared, and so completely macerated as to be held in solution in water, which is allowed to evaporate till it is of sufficient consistence for working, is called plasterers' putty.

Setting may be either a second coat upon laying or rendering, or a third coat u on "floating," which will be hereafter described. The term "finishing" is applied to the third coat when of stucco, but "setting" for paper. The setting is spread with the smoothing trowel, which the workman uses with his right hand, while in his left he uses a large flat-formed brush of hog's bristles. As he lays on the putty or set with the trowel, he draws the brush, full of water, backwards and forwards over its surface, thus producing a tolerably fair face for the work.

Floating.—Work which consists of three coats is called floated; it takes its name from an instrument called a float, which is an implement or rule moved in every direction on the plaster while it is soft, for giving a perfectly plane surface to the second coat of work. Floats are of three sorts: the hand-float, which is a short rule that a man by himself may use; the quirk float, which is used on or in angles; and the Derby, which is of such a length as to require two men to use it.

Plaster, float and set is the term for three coats of plaster on laths. The first or pricking-up coat is of coarse stuff put on with a trowel to form a key behind the laths, and about ½ or ¾ in. thick on the laths: while it is still moist it is scratched or scored all over with the end of a lath in parallel lines 3 or 4 in. apart, the scorings being made as deep as possible without exposing the laths; the rougher the edges are the better, as the object is to produce a good key for the next coat. When the pricking-up coat is sufficiently dry not to yield to pressure in the slightest degree, the second coat or floating is put on. The floating is of fine stuff with a little hair mixed with it; ledges or margins, 6 or 8 in. wide, and extending across the whole width of a ceiling or height of a wall, are made at the angles and at intervals of about 4 ft. apart throughout: these must be made perfectly in one plane with each other with the help of straight-edges. These ledges are technically called "screeds." They form gauges for the rest of the work, and when they are a little set the spaces between them are filled up flush, for which a Derby float or a long straight-edge is used. The screeds on ceilings ought to be levelled, and those on the walls plumbed. When the floating is sufficiently set, it is swept with a birch broom for the third coat or setting. The third, or setting coat, should be of plasterers' putty, if the ceiling or wall is to be whitened or coloured. If it is to be papered, the third coat should be of fine stuff, with a little hair in it. If it is to be painted, the third coat should be of bastard stucco trowelled.

Bastard stucco is of three coats, the first is roughing in or rendering, the second is floating, as in trowelled stucco; but the finishing coat contains a small quantity of hair behind the sand. This work is not hand-floated, and the trowelling is done with less labour than what is termed trowelled stucco.

Trowelled stucco, which is the best sort of plastering for the reception of paint, is formed on a floated coat of work, and such floating should be as dry as possible before the stucco is applied. In the last process, the plasterer uses the hand float, which is made of a piece of half-inch deal, about

9 in. long and 3 in. wide, planed smooth, with its lower edges a little rounded off, and having a handle on the upper surface. The ground to be stuccoed being made as smooth as possible, the stucco is spread upon it to the extent of 4 or 5 ft. sq., and moistening it continually with a brush as he proceeds, the workman trowels its surface with the float, alternately sprinkling and rubbing the face of the stucco, till the whole is reduced to a fine even surface. Thus, by small portions at a time, he proceeds till the whole is completed. The water applied to it has the effect of hardening the face of the stucco, which, when finished, becomes as smooth as glass.

Ceilings are set in two different ways; that is the best wherein the setting coat is composed of plaster and putty, commonly called gauge. Common ceilings are formed with plaster without hair, as in the finishing coat for walls set for paper.

Pugging is plaster laid on boards, fitted in between the joists of the floor to prevent the passage of sound between two stories, and is executed with coarse stuff. In the country, for the exterior coating of dwellings and outbuildings, a species of plastering is used called "roughcast." It is cheaper than stucco and therefore suitable to such purposes. In the process of executing it, the wall is first pricked up with a coat of lime and hair, on which, when tolerably well set, a second coat is laid of the same materials as the first, both as smooth as possible. As fast as the workman finishes this surface, another follows him with a pailful of the roughcast, with which he bespatters the new plastering, so that the whole dries together. The roughcast is a composition of small gravel, finely washed, to free it from all earthy particles, and mixed with pure lime and water in a state of semi-fluidity. It is thrown from the pail upon the wall, with a wooden float, about 5 or 6 in. long, and as many wide, formed of ½ in. deal, and fitted with a round deal handle. With this tool the plasterer throws on the roughcast with his right hand, while in his left he holds a common whitewashers' brush dipped in the roughcast, with which he brushes and colours the mortar and the roughcast already spread, to give them, when finished, a uniform colour and appearance.

Miscellaneous Memoranda.

2 hods plaster, etc. (about) = 1 bushel.

2 bushels of grey lime = 1 bag.

3 bushels of blue lias = 1 bag.

3 bushels of sand = 1 barrel or basket.

21 bushels of sand or lime = 1 yard.

3 bushels of cement = 1 sack.

4 bushels of Portland = 1 cask.

5 bushels of Roman = 1 cask.

⅝ full bushel of Parian cement = 1 hod.

36 bushels sand = 1 load.

14 lb. plaster = 1 bag.

7 bags plaster = 1 bushel.

1¼ bushel plaster = 1 cwt.

1 sack plaster = 2 cwt.

3¾ cwt. Portland cement = 1 cask.

1 firkin plaster = ⅜ cwt.

1 firkin of double size = 48 lb.

2 dozen whiting = 1 cwt.

30 bundles of laths = 1 load.

1 bundle of laths contains (nominally) 500 ft.

Single fir laths are less than ¼ in. thick.

Double fir laths are about ⅜ in. thick.

1 bundle of laths and 500 nails will cover about 5 superficial yards.

12 lb. whiting, ¼ lb. blue-black, 1⅞ gal. of size are required for 100 yd. (superficial) "once" done; 21 lb. of whiting, ⅜ lb. blue-black, 2⅜ gal. of size, if "twice" done.

1 cub. yd. of chalk lime, 2 yd. of road drift or sand, and three bushels of hair will cover 75 yd. of render and set on brick, and 70 yd. on lath, or 65 yd. plaster or render two coats, and set on brick, and 60 yd. on lath. Floated work will require about the same as two coats, and set.

Coarse Stuff.—Common lime mortar with a small quantity of hair; or, by

volumes, lime paste, 1 part; sand, 2 to 2¼ parts; hair ⅛ part.

Thickness of Compo.	½ in.	¾ in.	1 in.
	yd.	yd.	yd.
1 bushel of cement will cover	2¼	1½	1⅛
1 bushel of cement and 1 of sand will cover	4½	3	2¼
1 bushel of cement and 2 of sand will cover	6¾	4½	3⅜
1 bushel of cement and 3 of sand will cover	9	6	4½

¾-in. is the usual thickness.

Fine Stuff.—Lime, slaked to a paste, with a moderate quantity of water, afterwards diluted to the consistence of cream, and then allowed to harden by evaporation to the required consistence for working.

Gauged Stuff is composed of from 3 to 4 parts of fine stuff and 1 part plaster of Paris, in proportions regulated by the rapidity required in hardening. For cornices, etc., the proportions are equal parts of each (fine stuff and plaster). (Spons' 'Builders' Price Book.')

Amount of materials required for 100 sq. yd. of plastering.

One-coat:—

Lime	1 cub. yd.
Sand	2 „
Hair	15 lb.

Two-coat (coat and set with fine stuff):—

Lime	2 cub. yd.
Sand	2 „
Hair	23 lb.

Three-coat (coat, float and set with fine stuff):—

Lime . .	2¼ to 2½ cub. yd.
Sand . .	2¼ „ 2½ „
Hair . .	26 lb.

The above would be either rendered on walls or plastered on laths.

Lathing:—

Laths	22 bundles
Nails, joists 12 in. apart	13 lb.
„ 16 „	10 „

PLATINUM DEPOSITS ON GLASS.

On Glass.—The following method of depositing brilliant films of platinum on glass was devised by Prof. Böttger. In order to succeed in coating porcelain or glass with a perfectly faultless film of platinum, of the brilliance of silver, it is indispensably requisite to make use of perfectly dry platinum chloride, which must be as free from acid as possible. To that end pour some oil of rosemary over the perfectly dry platinum chloride in a small porcelain mortar and knead it up with the pestle, renewing the oil about three times, and continue this operation until at length there is produced from the brownish-red chloride a soft plaster-like mass, the colour of which is as black as pitch, and wherein no particles of undecomposed platinum chloride are discoverable. The oil of rosemary assumes hereby a more or less yellow colour in consequence of its partially taking up chlorine from the platinum chloride. When at length we have arrived at converting the whole of the platinum chloride into the black plaster-looking mass spoken of, rub it well up with the pestle, after pouring the oil of rosemary off, with about five times its weight of oil of lavender, and continue to do so until it has become a perfectly homogeneous thin fluid. It must then be left to stand for ½ hour or so, for it is not until after that interval that it can be used with advantage for platinising. For the production of the brilliant platinum film, all that is now required is to apply the mass as uniformly as may be, and in the thinnest possible coat, to the objects of porcelain, earthenware, or glass by means of a soft delicate brush. The thinner the coat of the above described preparation the more brilliant the film of platinum subsequently proves. When the articles have been gone over as thinly as possible with the fluid conformably with these instructions, all that is required further is to subject them for a few minutes to a very low scarcely perceptible red heat, either in a muffle or in the flame of a Bunsen's gas blow-pipe used with caution. The articles receive from this baking (supposing always that the temperature described has not been exceeded), without requiring any subsequent treatment, an incomparably beautiful lustre, as brilliant as silver. If, by any oversight, the coating of platinum upon the articles has turned out faulty, or in the case of breakages occurring during the baking, every trace of the metal may be recovered with facility, from the objects that have suffered, by means of the following very simple galvanic process, without being obliged to have recourse to the use of aqua regia. Nothing more is required than to pour common hydrochloric acid over them, and then touch them with a zinc rod. On doing this, as quick as lightning, in consequence of the hydrogen evolved both at the upper and lower surface of the film of platinum which acts as the negative pole, we see the shining metallic coating peel off in the form of infinitely thin leaves from the base of porcelain or glass, and, notwithstanding the specific gravity of the metal, ascend partially and float on the surface of the acid. On separating the hydrochloric acid by the use of a filter, the whole of the platinum which would be otherwise lost, is recovered, so that no complaint arises as to the waste of any of the metal in question. Prepare at once only as much of the platinising fluid as is required for the day's use, inasmuch as it loses in efficiency by keeping. That which forms the active principle in the fluid, which results from treating platinum chloride with oil of lavender, as above described, is an organic platinum salt, which in point of fact, one can obtain, after some time, in the form of small elongated octahedral crystals, of a pale yellowish colour, by washing out carefully with alcohol a tolerable quantity of the fluid. The crystals have the

property of taking fire with a brilliant flame on being brought near a lighted candle, leaving a residue of compact platinum of dazzling whiteness.

POLISHING AND POLISHES.

(*See also* BLACKING LEATHER POLISHES, BURNISHING, EBONISING, GILDING, LACQUERING, POLISHING - WHEELS, STAINS AND STAINING, VARNISHING, ETC.)

French Polishing.—(1) As in varnishing, a warm, dry atmosphere is essential, and all draughts of cold air from door or window must be avoided.

Pour a little linseed-oil into a cup and some polish into another; take a piece of woollen rag a few inches square, and having rolled it up into a ball saturate it with polish, and cover with a piece of linen or muslin drawn tightly over it. In this way the rubbers or pads are prepared, and they should, when taken by the fingers of the right hand, be held in such a manner as to draw the linen covering tight, and present a smooth, slightly convex surface to work with; apply one drop of oil and one drop of polish to the surface of the pad, and it is ready for use. Care must be taken that the material of which the rubbers are made is well washed and free from starch or soap.

The work having been thoroughly smoothed with fine glasspaper and the dust wiped away with a clean cloth, the polishing is commenced with free, continuous and uniform circular strokes, applied with very slight pressure, and gradually traversing the whole surface, observing not to do more than a square foot at a time; the same process is repeatedly continued, varying the position of the strokes as much as possible, but keeping them about the same size, and taking care that every portion of the surface receives an equal but not excessive quantity of polish, which is regulated partly by the degree of pressure on the rubber, and partly by squeezing it between the fingers.

The process of polishing is continued until the grain of the wood appears to be thoroughly filled up, and the surface exhibits a uniform appearance,

well covered with a thin coat of polish. It is then allowed to stand for an hour or two to become thoroughly hard, when it is rubbed with very fine glass-paper, to smooth down all the irregularities of the grain of the wood, and also of the polish The polishing is then repeated, and, if it should be found necessary, it is again smoothed, and the polishing is persevered in until the surface appears quite smooth, and uniformly covered with a thin and tolerably bright coat of polish, but which will, nevertheless, show cloudy marks from the rubber, owing to the presence of the oil, which is finally removed with a few drops of spirits of wine applied on a clean rubber and covered with a clean soft linen rag, with which the work is rubbed with very light strokes, applied first with a circular motion, and when the surface appears nearly dry, straight strokes are taken lengthways of the grain of the wood, and traversed entirely off the ends of the work; this is continued until the rubber and work are both quite dry, when the polishing will be completed. The polish, however, will be partly absorbed by the wood in the course of a day or two; and therefore it is desirable to repeat the process after a lapse of a few days, first slightly rubbing down the former coat with very fine or nearly worn-out glasspaper.

(2) The operation of French polishing consists in nothing more than the distribution of a solution of lac in spirits of wine—by means of a rubber made of cotton wool and calico rag—over the surface of wood, using pressure, until the pores are entirely filled, and the strata of deposited resin adhering form a smooth, hard, and brilliant gloss. The first operation in polishing is called "filling-in"—that is, some substance, other than polish, is rubbed into the pores of the wood to economise time and materials; in fact, this is the foundation on which the superstructure is built; consequently it is of no small importance, as good beginnings generally make good endings. The general modes of filling-in are several, the following being a few of them: Plaster of Paris is the most common ingredient, and is thus used. Roll up a piece of rag into a rubber, saturate it with water, dip it into the plaster, taking up a goodly supply, and rub it well into the pores, bit by bit, until you have as it were plastered or whitewashed the article of furniture all over, taking care, however, to wipe off the superfluous plaster with another piece of dry rag, before it sets; otherwise there will be difficulty in getting an even surface without much papering. When this is done let it stand till thoroughly dry.

Another method is to beat up some plaster in water sufficiently thin to prevent setting too soon, and go over the wood with this as before. Some beat up plaster in linseed-oil, and use that alone; while others add a little polish stirred into the above, to cause it to set a little quicker. Another compound is Russian fat, plaster of Paris, and some pigment to suit the wood it is intended for; these are heated together and laid on hot, wiping off the superfluous mass with rag. The only advantage in the two last being, that polishing can be commenced upon them directly, whereas the others have to dry first. Some even utilise mutton-suet in its solid form, to rub into the pores, others melt size, and stir in plaster, using this hot, which is as good as any; for, when dry, it does not absorb so much oil as the plaster and water methods.

A system that was practised for some years consists in dissolving alum in cold water, until the water will take up no more; in other words, a saturated cold solution; powder some whiting, and pour it into the alum solution; decomposition with effervescence takes place, the sulphuric acid quitting the alumina, and seizing the lime by its superior affinity, driving off the carbonic acid, which is set free, thus producing sulphate of lime, with a little alumina and potash, or ammonia, instead of carbonate of lime and sulphate of alumina.

This is cheap, easily made, and is a powerful astringent; containing more acid than plaster, which is also sulphate of lime with the greater part of its acid driven off by heat.

The next operation consists in oiling the wood with linseed-oil; but previous to this, it should be well papered with glasspaper No. 1, or coarser if required; then take a piece of cotton wool, saturate it with the oil, and go carefully over every part that shows white from the filling-in, taking care to "kill" that filling-in, as it is called, or totally obliterate it. This done, wipe all the superfluous oil off, thoroughly; bearing in mind, the less there is of this in your foundation, the more solid will be your work.

Now roll up a piece of cotton wool into a compact and suitable rubber, pour into it as much polish as it will hold; cover it over with a piece of open calico rag, and pass this over every part in a horizontal direction, floating the surface with polish, which must then be set aside to sink and harden. There should be no attempt at polishing in this operation, the first consideration being to obtain a good concrete to build upon.

When properly dry, the fibre, which has risen from the floating coat of polish, must be thoroughly papered down with glasspaper No. 1½, and if upon a flat surface, a cork rubber will be necessary; for no work, however highly-laboured out, will acquire an even and proper surface unless it is well grounded. A practical man knows the importance of this; how it saves him time and labour; therefore he is very careful not to begin polishing before his foundation is perfectly satisfactory. This being so, the process of polishing is commenced. The rubber used for floating the work will answer for this purpose, provided it has been kept moist by excluding air from it.

The rubber being charged with polish much less copiously than in floating, a piece of calico rag is placed over it, and so twisted up, that the excess of rag and rubber is confined in the palm of the hand; and with this arrangement the polish is conveyed to the wood. The polisher now proceeds to body-in his work, using, occasionally, pumice powder sprinkled over the surface, which not only keeps that surface smooth, but materially assists in filling the pores; in fact, it is invaluable in the hands of a skilful man.

As a solid foundation is a great desideratum, he applies as little oil as possible; just sufficient to prevent dragging of the rubber, which would produce a harsh and uneven appearance. The natural repugnance between oil and spirit, as manifested in their unwilling amalgamation, is strong evidence against their friendly union by compulsion; therefore, to prevent serious eruptions, no more is used than the polish can conveniently neutralise. Rubber after rubber is applied with varied pressure, now lightly, now heavily, working in small circles, a beautiful dull smear following its course as the surface approaches to fulness; the rubber slightly biting, partly from the adhesive nature of the polish, but more from the partial vacuum produced by the flat rubber on the smooth surface of the wood. The pores being filled, and the work presenting a solid and compact body, it is set aside for some hours to settle and harden. In a day or two the polisher takes it up again, and although full when set aside, it is not so full now, having slightly sunk, and showing just a little of the pores. With No. 0 paper he frees the surface of any slight imperfections that may appear, or if it is at all unsatisfactory or presents an uneven surface he cuts it down with glasspaper No. 1, in order that it may with this body be perfectly level and mirror-like. This done, he proceeds as before to body-up the work, using great care in working it up to a point approaching a finish, full, clear, and hard; so that it shall require as little wetting as possible at the next, or finishing coat; which done he sets it aside again to harden.

On taking it up again, he removes

any dust that may have settled upon it, by wiping it all over; thus also removing any little oil that may have sweated out from the previous operation. He then selects an old rubber, one that has become close and compact from long use and pressure, from his rubber canister, where he keeps various sizes to suit the area of his work; this canister being fitted with a cover, excluding air, keeps the rubbers constantly moist and ready for use. The why and wherefore of that old rubber is this: by the closeness of its texture, it has a less capacity for polish, and consequently gives that polish out much more sparingly than would a new one, made of the same material; and as in this final operation there must be no approach to wetness, its use is obvious. He charges this rubber with half-and-half, that is, half polish and half clear spirit, only just sufficient that when forced into the rubber by squeezing, it shall be a little moist; for if the body is wetted, it will redissolve, and greatly deteriorate the quality of the finished surface. Placing over his rubber a piece of soft calico rag, and twisting them up in a proper manner, with a drop of oil applied to its surface, he passes it over the work in a horizontal direction until the whole has received a portion, and the rubber is in a fit state to be worked. He has now arrived at the most important part of his work, namely, that of giving to it that unexceptionable glaze, which is the genuine stamp of a well-finished piece of work.

The polisher exercises the utmost care and ingenuity in the manipulation of his rubber, judging of its proper working by the dull, satiny smear, as he calls it, following the course of his movements; which dull smear consists of an inconceivably fine stratum of resin, the spirit from which is driven off by friction, assisted by temperature. Two chargings of the rubber should be sufficient for this operation, and with these he so elaborates his work that, the rubber being completely dried out, the surface of his work is smearless, hard, and brilliant; and should require nothing more, although it is customary to give it a final touch by means of a rubber of soft calico rag, slightly damped with clear spirit, and passed lightly over the surface until dry.

Work thus executed will stand for years, creditable both to the workman who did it, and the employer who turns it out; the only thing required to keep it in order being to keep it clean and dry by frequent wiping with soft dusters.

It is certainly much to be regretted that such a thing as time should interfere to mar work which otherwise could be made exceedingly beautiful; especially with a trade in which time itself is such an essential and even indispensable requisite; yet such is the case, and the consequence is, that 90 per cent. of those employed in polishing are totally ignorant of what degree of proficiency they are capable. In the preceding example, rules are given limiting the operations to three; but in the shops of good firms that number is often exceeded; while in minor houses it oftener consists of one or two. The carrying out of the foregoing work in polishing-shops is usually as follows: the filling-in, the oiling, and often the floating, are done by the boys, or learners; the bodying and finishing by the men.

(3) The original recipe for the polish is as follows. To 1 pint spirits of wine add ¼ oz. shellac, ¼ oz. lac, ¼ oz. sandarach, placing it over a gentle heat, frequently agitating it until the gums are dissolved, when it is fit for use. Make a roller of list, put a little of the polish upon it, and cover that with a soft linen rag, which must be slightly touched with cold-drawn linseed-oil. Rub them on the wood in a circular direction, not covering too large a space at a time, till the pores are sufficiently filled up. After this, rub in the same manner, spirits of wine, and a small portion of the polish added to it, and a most brilliant effect will be produced.

The original process, with little variation, or simplifying, has kept in use ever since, not because it is so perfect as not to admit of improvement, for it has never been so compounded that surfaces produced from it would resist a very high degree of heat without suffering partial decomposition, and consequently it could not be employed for many purposes which otherwise it is desirable that it should be, but chiefly because those who make polish—that is, the wholesale makers—are not themselves sufficiently acquainted with its requirements.

With regard to its lustre-yielding properties, it is everything that can be desired; and surely the resources of chemistry would not be exhausted in discovering something that would make it more impervious to heat. In the hands of competent persons it is not unreasonable to suppose that some beneficial result might be arrived at, namely, the combination of a heat-resisting with its lustre-yielding properties. As an example of what is required, one may point particularly to the dining-tables of the ante-French polishing period, which were brought up to a marvellously brilliant surface by means of linseed-oil and years of hard rubbing, a surface that would resist equally the heat of the hot dishes and the tricklings of wine from the decanters. The lac substance, of itself a yellowish-brown colour, semi-transparent, and very brittle, produces, when dissolved in spirits of wine, a solution of yellowish-brown colour, which, when applied to woods of various and delicate shades, such as the white, silver, gold, purple, black, etc., which enter into marquetry, was found to communicate a false hue, and tended to mar the harmony it was wished to improve. Hence arose the necessity for bleaching it, so that a solution might be prepared suitable for any combination of colours without destroying or injuring their effect. But, as there is no good without an evil, the process of bleaching acts very detrimentally on the more soluble constituents of the lac, depriving them of a considerable portion of their original body and density.

This is easily proved by pouring a solution from one bottle to another, when it will be seen to flow in a light, frothy-like stream, much less dense than a solution of the unbleached article. Further evidence is in the fact that polishers using it in high temperatures are commonly heard to say that they cannot get it to lie flat, a term as applicable and correct as any, perhaps, when carefully examined; for the heat, acting upon the chlorine, which has undoubtedly entered into combination with it in the process of bleaching, causes that gas to expand, so that the more polish he applies, the more gas he has to contend with, in impeding that cohesion and crystallisation which he is endeavouring to bring about.

Polish, under its most favourable conditions, is a compound so liable to change by variations of temperature, humidity, pressure, etc., that its use is very variable and uncertain. Lac in its dry state, and in a temperature higher than is ever required for polishing, is totally unaffected; but put into boiling water, it speedily becomes soft and plastic, and on being removed from the water resumes its original character of hardness quickly from its inferior capacity for heat. Not so is it with spirits of wine, its menstruum; this has an extraordinary capacity for heat, inasmuch as that it will volatilise in the ordinary state of the atmosphere, its briskness increasing with increase of temperature.

Now, although boiling water has no action on lac, other than to soften it for the time it is immersed in it, having no power to dissolve it of itself, still that substance is very differently affected when in combination with spirits of wine, its true solvent, the strong affinity for heat of the spirit entirely overcoming the feeble capacity for it in the lac; and so strong is the affinity of the spirit for the lac, that it

separates its last portions from that substance, when fairly combined, with the greatest difficulty. Thus the necessity, in polishing, of a moderate degree of heat, to assist that produced by the friction of the rubber, in forcing out that clinging portion of spirit before solidity and brilliance can be obtained.

The most favourable temperature for polishing appears to be 60°–70° F. (16°–21° C.); ascending above this, one portion of the spirit evaporates before a proper distribution of the lac can be brought about, while the other portion, which adheres so tenaciously to that substance, impedes its solidification. Descending below that degree, there is a tendency in the materials to chill, the more especially if the room in which the work is done be at all damp, the activity of the evaporation being checked by the absence of heat necessary for its conveyance. This is an evil more easily remedied than the former, as in most cases all that is required is to light a fire, and by that means supply the deficiency. Not so convenient would it be in the height of summer, with the thermometer indicating 80° or 90° F., to remove the work to an ice-house; and being so removed, the remedy would be worse than the evil. But of all the injurious influences attending polishing, none is comparable to humidity. If the atmosphere be saturated with moisture, as it not unfrequently is, when the clouds, or aqueous vapour, instead of being buoyed up in the sky, hang about the earth's surface, even though the thermometer stands at 70° F., as favourable a point as any, polishing becomes extremely difficult; the materials appear to be so completely neutralised, as to render them incapable of performing their office. Increased pressure and friction seem inadequate to supply or make up for the atmospheric derangement. The cause of this may perhaps be thus explained: All liquids in becoming solids part with heat. Now this liquid, being compounded of spirit, not only has it become enfeebled, being spread on a surface, and thus exposed to a body for which it has the strongest affinity, but becomes so diluted by it, that it has lost in a great degree the power of evaporation or means of parting with heat, consequently assuming the solid form with difficulty.

Atmospheric pressure is undoubtedly the surest guide to the experienced polisher, showing him the power nature is employing for his advantage, or detriment; for, carefully observing the movements of the mercury, he will not fail to realise the fact, that as it ascends his labour will be considerably lightened, while, on the other hand, it will be greatly augmented by a corresponding depression — regard being paid, of course, to temperature.

It may be proper, however, to acknowledge that this theory rests on supposition. It is nevertheless a fact, that when the air is most suitable to ourselves—when it is bracing and buoyant—infusing as it were more life into us, it is also found to be more suitable for the performance of our work. It must not, however, be inferred, from these remarks, that polish will not work under the influence of these atmospheric changes, for it is found to do so in our climate, even under its extremest fluctuations; but what is meant is, that its effects are less under a low than under a high pressure, in a moist than in a dry atmosphere, and either in a low or high temperature, than in a medium one.

From observations of the effects of polish, together with its daily use, the following conclusions present themselves, namely, that it is not in the nature of the materials, as at present compounded, to withstand the antagonistic influences constantly opposed to them; that the effects produced on polish by variations of temperature, show the necessity of so preparing it as to render it proof against such changes; and, finally, that it be so prepared as to withstand a much higher degree of heat than in its present simple form it is able to do. (John Dalton.)

(4) The following directions for polishing are said to represent the practice followed in the United States. It should be remembered that as regards the polishing the different climatic conditions should be allowed for, as the normal dryness of the atmosphere in the United States favours many processes in polishing which require special conditions in this country. In preparing and filling-in, first see that the work is smooth and free from dust, then oil the parts to be polished with raw linseed-oil, and prepare filling-in. That is done with a mixture of whiting and turpentine made into a paste; rub well into the grain of the wood with a piece of rag or tow, and wipe clean off. For mahogany, add rose pink to colour; for oak, birch, or ash, add a little yellow ochre. Work to be polished white requires no colour in the filler. For polishing, prepare a rubber of cotton-wadding, in size according to job; wet it with polish, and, with the point of the finger, put a little raw linseed-oil on it, then cover the rubber with a piece of rag; twist the end of the rag and keep it tight over rubber, and proceed to rub the job over in a circular direction, keeping rubber constantly in motion; when dry, wet it again, with oil, and continue to work it until a sufficient body of polish has been obtained, then place it on one side for about 12 hours to sink. Polish always sinks after being bodied-up. In spiriting off or finishing, if the work be sunk in before spiriting, give a few rubbers of polish, then prepare a rubber the same as for bodying-up, and wet it with proof alcohol from a bottle with a little cut out of the side of the cork, so that the spirits will drop out: 3 or 4 drops will be enough for a learner to put on at one time. Take care the rubber is not too wet, or it will soften the polish and tear it up. When the rubber is nearly dry, rub smartly until all the job is clear of oil and rubber-marks. No oil is used in finishing. Varnishing is done with a camel-hair brush for turned or carved work. First give the work 2 or 3 rubbers of polish, and then, having stained the varnish, proceed to give the work a coat, passing the brush smartly over the job, taking care to keep it level, and do not go too often over the same place; 2 or 3 coats may be given in the same manner, rubbing down after each coat with fine glasspaper. Work that is varnished should stand 12 hours before it is handled. For glazing, prepare the rubber the same as for polishing, but make it much wetter, and pass it smartly over the work from right to left. Always begin at the same end of the job, and bring the rubber straight to the other end in one stroke; do not go too often over the same place or you are apt to tear it up. This is used for common work in place of spiriting, and for mouldings, etc. A rubber of spirits, passed quickly over a job that has been glazed, very much improves it, and makes it smooth, but it must be done very lightly and quickly, and passed straight up and down.

(5) A correspondent of the Boston (U.S.) 'Cabinet-Maker' gives the following details of the methods of polishing wood. He first describes the method of polishing pianos used in all first-class factories. The same process will answer for any other piece of furniture by merely substituting for the scraping, where scraping is not practicable, a filling, properly coloured. First, give the work 3 coats of scraping or No. 2 furniture varnish, allowing each coat to become perfectly hard before applying the next; then scrape off the varnish with a steel scraper, properly sharpened on an oil-stone, and in scraping be careful not to cut into the wood, but merely remove the varnish from the surface, leaving the pores filled. Smooth with No. 1 sandpaper, and the work will be ready for the polishing varnish, 4 coats of which must be laid on with a brush, allowing each to harden. To determine the time required for the hardening, one coat will not be ready for the next until it is so hard that you cannot make any impression on it with your thumb-nail. The 4 coats having been

put in, and the work having stood a few days—and the longer the better—rub down with fine-ground pumice and water, applied with a woollen rag. The work must be rubbed until all lumps and marks of the brush are removed; wash off with a sponge and dry with a chamois skin; let the work stand out in the open air for a day or two, taking it into the shop at night. The work should now receive 2 coats more of polishing varnish and a second rubbing, after which it is ready for polishing. Furniture may be polished after the first rubbing, and in that case the polishing is performed with lump rotten-stone and water applied with a woollen rag. Put plenty of rotten-stone on your work, with water enough to make it work easy. Rub until all marks and scratches are removed. Rub the rotten-stone off with your bare hand, keeping the work wet. What cannot be removed with the hand should be washed off with a sponge. After drying with a chamois skin, bring up the polish with the palm of your hand, moving it lightly and quickly, with a circular motion, over the work. Clean up the work with a piece of soft cotton, dipped into sweet oil, and lightly touch all the white spots and marks of the rotten-stone. Remove the oil with wheat flour, applied with soft cotton, and finally dust off with a soft rag or silk handkerchief. The following method is known as the shellac or French polish. In preparing for this process, add to 1 pint shellac varnish 2 tablespoonfuls of boiled oil; the two to be thoroughly mixed. If you want the work dark add a little burnt umber; or you can give the work any desired shade by mixing with the shellac the proper pigment in the dry state. Apply the shellac thus prepared with a small bunch of rags held between your fingers. In applying it, be particular in getting it on smooth and even, leaving no thick places or blotches. Repeat the process continually until the grain is filled and the work has received sufficient body. Let it stand a few hours to harden, and then rub your work lightly with pumice and oil, applied with a rag. A very little rubbing is required, and this is to be followed by the cleaning of the work with rags as dry as possible. With a piece of muslin wet with alcohol, go over the work 2 or 3 times, for the purpose of killing the oil. Have ready ¼ lb. pure gum shellac dissolved in 1 pint 95 per cent. alcohol. With this saturate a pad made of soft cotton, covered with white muslin, and with the pad thus formed go over your work 2 or 3 times. To become proficient in this work, practice and close attention are required.

Polishing in the Lathe.—The beauty of good work depends on its being executed with tools properly ground, set, and in good order; the work performed by such tools will have its surface much smoother, its mouldings and edges much better finished, and the whole nearly polished, requiring, of course, much less subsequent polishing than work turned with blunt tools. One of the most necessary things in polishing is cleanliness; therefore, previous to beginning, it is as well to clear the turning-lathe or work-bench of all shavings, dust, and so on, as also to examine all the powders, lacquers, linen, flannel, or brushes which may be required; to see that they are free from dust, grit, or any foreign matter. For further security, the polishing powders used are sometimes tied up in a piece of linen, and shaken as through a sieve, so that none but the finest particles can pass. Although, throughout the following methods, certain polishing powders are recommended for particular kinds of work, there are others applicable to the same purposes, the selection from which remains with the operator; observing this distinction, that when the work is rough and requires much polishing, the coarser powders are best; but the smoother the work, the less polishing it requires, and the finer powders are preferable.

Soft woods may be turned so smooth

as to require no other polishing than that produced by holding against it a few fine turnings or shavings of the same wood whilst revolving, this being often sufficient to give it a finished appearance; but when the surface of the wood has been left rough, it must be rubbed smooth with polishing paper, constantly varying the position of the hand, otherwise it would occasion rings or grooves in the work. When the work has been polished with the lathe revolving in the usual way, it appears to be smooth; but the roughness is only laid down in one direction, and not entirely removed, which would prove to be the case by turning the lathe the contrary way, and applying the glasspaper; on which account work is polished best in a pole-lathe, which turns backwards and forwards alternately, and therefore it is well to imitate that motion as nearly as possible.

Mahogany, walnut, and some other woods of about the same degree of hardness, may be polished by either of the following methods: Dissolve by heat, so much beeswax, in spirits of turpentine, that the mixture when cold shall be of about the thickness of honey. This may be applied either to furniture or to work running in the lathe, by means of a piece of clean cloth, and as much as possible should then be rubbed off by means of a clean flannel or other cloth. Beeswax alone is often used; upon furniture it must be melted by means of a warm flat iron; but it may be applied to work in the lathe by holding the wax against it until a portion of it adheres; a piece of woollen cloth should then be held upon it, and the lathe turned very quickly, so as to melt the wax; the superfluous portion of which may be removed by means of a small piece of wood or blunt metal, when a light touch with a clean part of the cloth will give it a gloss. A very good polish may be given to mahogany by rubbing it over with linseed-oil, and then holding against it a cloth dipped in fine brickdust. Formerly nearly all the mahogany furniture made in England was polished in this way.

Hard woods are readily turned very smooth; fine glasspaper will suffice to give them a very perfect surface; a little linseed-oil may then be rubbed on, and a portion of the turnings of the wood to be polished may then be held against the article, whilst it turns rapidly round, which will, in general, give it a fine gloss. Sometimes a portion of shellac, or rather of seed lac, varnish is applied upon a piece of cloth, in the way formerly described. The polish of all ornamental work wholly depends on the execution of the same, which should be done with tools properly sharpened; and then the work requires no other polishing but with a dry hand-brush, to clean it from shavings or dust, this trifling friction being sufficient to give the required lustre.

Stopping or Fillers for French Polishing.—(1) Plaster of Paris, when made into a creamy paste with water, proves a most valuable pore-filling material. It is to be rubbed, by means of a coarse rag, across the woody fibre into the holes and pores, till they are completely saturated, and then the superfluous plaster on the outside is to be instantly wiped off. The succeeding processes are technically termed papering, oiling, and embodying.

(2) When finely-pounded whiting is slaked with painters' drying oil, it constitutes another good pore-filler. It is applied in the same manner as the preceding, and it is recommended on account of its quickly hardening and tenacious virtues as a cement; sometimes white-lead is used in lieu of the whiting.

Before using either of these, or other compositions for the same purpose, it is best to tint them to correspond exactly with the colour of the article it is intended to polish.

(3) Holes and crevices may be well filled up with a cement that is made by melting beeswax in combination with resin and shellac.

(4) A paste of whiting and turpentine rubbed well crossways into the grain of the wood.

(5) After the first oiling of the work, shake a muslin bag, containing smoothly ground pumice stone, over it. Dry plaster of Paris can be used in the same way. Rub in.

(6) For oak, ash, or satin-wood, 1 lb. mutton suet or tallow and 2 lb. plaster of Paris. Melt together, and rub well into the grain of the wood with a piece of rag.

(7) For mahogany, the fillers should be coloured with rose pink. For walnut colour, with umber or rose pink. For oak, birch, and ash, use a little yellow ochre. Work to be polished white, requires no colour in the filler.

French Polishes.—(*a*) 1 pint spirits of wine, ¼ oz. gum copal, ¼ oz. gum arabic, and 1 oz. shellac. Bruise the gums and sift them through a piece of muslin. Place the spirits and the gums together in a vessel closely corked, near a warm stove, and frequently shake them; in two or three days they will be dissolved. Strain through a piece of muslin, and keep corked tight.

(*b*) Dissolve 1½ oz. shellac, ¼ oz. sandarach, in ½ pint naphtha.

(*c*) Pale shellac, 2½ lb.; mastic and sandarach, each 3 oz.; spirits, 1 gal. Dissolve, and add copal varnish, 1 pint; mix well by agitation.

(*d*) Shellac, 12 oz.; wood naphtha, 1 qt.; dissolve, and add ½ pint linseed-oil.

(*e*) Crush 3 oz. shellac with ½ oz. gum mastic, add 1 pint methylated spirits of wine, and dissolve.

(*f*) Shellac, 12 oz.; gum elemi, 2 oz.; gum copal, 3 oz.; spirits of wine, 1 gal.; dissolve.

(*g*) Shellac, 1½ oz.; gum juniper, ½ oz.; benzoin, ½ oz.; methylated alcohol, ½ pint.

(*h*) 1 oz. each of gums mastic, sandarach, seed-lac, shellac, and gum arabic; reduce to powder; then add ¼ oz. virgin wax; dissolve in a bottle with 1 qt. rectified spirits of wine. Let it stand for 12 hours, and it is then fit for use.

(*i*) 1 oz. gum-lac; 2 dr. mastic in drops; 4 dr. sandarach; 3 oz. shellac; ½ oz. gum dragon. Reduce the whole to powder.

French Polish Reviver.—(*a*) Linseed-oil, ½ pint; spirits of camphor, 1 oz.; vinegar, 2 oz.; butter of antimony, ½ oz.; spirit of hartshorn, ½ oz.

(*b*) ½ gill vinegar; 1 gill spirits of wine; 1 dr. linseed-oil.

(*c*) Naphtha, 1 lb.; shellac, 4 oz.; oxalic acid, ¼ oz. Let it stand till dissolved, then add 3 oz. linseed-oil.

(*d*) Pale linseed-oil, raw, 10 oz.; lac varnish and wood spirit, of each 5 oz. Mix well before using.

Polishing Mahogany.—The wood having been stained, paper off smooth with No. 0 glasspaper enough to give an even surface. Add ½ gill French polish, to ¼ oz. best dragon's blood, well mix and strain through muslin; polish as usual; if wanted very dark, apply a little dragon's blood to the rubber, but the rubber must be covered twice with linen rag.

Ebony.—Add ¼ oz. best drop black to ½ gill French polish. Polish as usual. A little of the drop black may be used on the inside rubber, but covered twice with linen rag.

Satin-wood or Maple.—¼ oz. chrome yellow to 1 gill light French polish; use as already described; a little chrome yellow on the rubber is desirable. In French polishing always use a drop of linseed-oil on the rubber.

Black and Gold Work.—The work to be polished and gilt must be stained with black stain; when quite dry, give a very weak solution of glue size, paper off smooth. Care must be taken not to remove the black stain with the paper. The part to be gilt must not be touched with the size, or the gold will not adhere so well; polish the part not to be gilt according to directions given for French polishing, using for the polish ebony; when the work is polished ready for spiriting off, lay the work on a table in a warm room, procure a portion of

the best oil gold size, pour in a cup, with a very fine stiff brush lay a thin even coat of gold size on the work, where the gold is to appear; let the gold size dry for 2 hours till it becomes tacky, then having the gold leaf ready, with great care lay a leaf (or part of a leaf, as required) on the cushion, cut to size required with the tip, lay the gold leaf on the sized work, then with a pad made of white wadding press the gold leaf in the crevices, blow off surplus leaf; let it stand aside to dry; when quite dry, polish gently with a very smooth pointed bone (or a dog's tooth is best) fixed in handle. Surplus parts and the edges should be cleaned off evenly afterwards. Finish the black work off with spirits. Very fine crevices may have gold leaf rubbed in with a brush, if used carefully, then blow off surplus parts. For commoner work, gold paint laid on with a brush answers very well.

White and Gold.—Brackets, console tables, whatnots, chairs, and other furniture are frequently done in white and gold. The grain of the wood should be first filled in with whiting and glue size, one or two coats well papered off and white polished, but the wood should not be finished off with spirits until gilt, leaving the last coat to be done when the gilding is finished; the gilding is done as in black and gold.

A Cheaper Mode, and much easier for the Amateur.—First well clean the article (if not new) with soda and water; when dry, scrape and paper all over, stop up cracks with white-lead and driers, one of driers to two of white-lead; mix some good white paint made of turps, driers, and white-lead, not oil. Give the article 3 coats, rubbing down the first coat when dry with pumice and water; when the third coat of paint is quite dry, proceed to gild as before described, using either gold leaf or gold paint; when so done, give the gold a coat of transparent enamel varnish, after which varnish the white work with clear copal varnish. Give the work 2 coats; it will set in a day. Small boxes and other fancy articles may be done by this process.

Polish for Turners' Work.—Dissolve 1 oz. sandarach in ½ pint spirits of wine; shave 1 oz. beeswax, and dissolve it in a sufficient quantity of spirits of turpentine to make it into a paste; add the former mixture to it by degrees; then, with a woollen cloth, apply it to the work while it is in motion in the lathe, and polish it with a soft linen rag; it will appear as if highly varnished.

For Wainscot.—Take as much beeswax as required, and placing it in a glazed earthen pan, add as much spirits of wine as will cover it, and let it dissolve without heat. Add either one ingredient as is required, to reduce it to the consistence of butter. When this mixture is well rubbed into the grain of the wood, and cleaned off with clean linen, it gives a good gloss to the work.

For Carved Cabinet-work.—Dissolve 2 oz. seed-lac, and 2 oz. white rosin, in 1 pint spirits of wine. This varnish or polish must be laid on warm, and if the work can be warmed also, it will be so much the better; at any rate, moisture and dampness must be avoided. Used with a brush for standards or pillars of cabinet-work. The carved parts of cabinet-work are also polished thus: varnish the parts with common wood varnish, and having dressed them off where necessary with emery paper, apply the polish used for the other parts of the work.

Copal Polish.—Melt with gentle heat finely-powdered gum copal, 4 parts, and gum camphor, 1 part, with ether to form a semi-fluid mass, and then digest with a sufficient quantity of alcohol.

For Wood Carving.—Take a piece of wadding, soft and pliable, and drop upon it a few drops of white or transparent French polish, according to the colour of the wood. Wrap the wetted wadding up in a

piece of old linen, forming it into a pad; hold the pad by the surplus linen; touch the pad with one or two drops of linseed-oil. Pass the pad gently over the parts to be polished, working it round in small circles, occasionally re-wetting the wadding in polish, and the pad with a drop or so of oil. The object of the oil is merely to cause the pad to run over the wood easily without sticking, therefore as little as possible should be used, as it tends to deaden the polish to a certain extent. Where a carving is to be polished after having been varnished, the same process is necessary, but it can only be applied to the plainer portions of the work. Plane surfaces must be made perfectly smooth with glass-paper before polishing, as every scratch or mark will show twice as badly after the operation. When the polish is first rubbed on the wood, it is called the *bodying in*; it will sink into the wood and not give much glaze. It must, when dry, have another body rubbed on, and a third generally finishes it; but if not, the operation must be repeated. Just before the task is completed, greasy smears will show themselves; these will disappear by continuing the gentle rubbing without oiling the pad.

Polishing Fretwork.—The wood is first well smoothed with fine glass paper, then covered with a thin coating of size, made from transparent glue, to prevent the varnish from sinking into the wood. When dry, pour some varnish into a saucer; take a fine camel-hair brush, and commence to varnish at one corner, gradually spreading over the whole surface. Take care that there is not too much varnish on the brush, or an even surface cannot be obtained. The first coating must be allowed to dry, which will take two or three hours. Take a sheet of the finest glasspaper, and when the first coating of varnish is perfectly dry, glasspaper the whole surface, and make it smooth as before. This done, with great care spread next coat of varnish on, always using the glasspaper when the surface does not turn out very smooth. The whole, when dry, may be rubbed well with a piece of worn woollen material till it is bright. To French polish the work, make the wood smooth as before. Then pour some prepared polish into a saucer, and some linseed-oil into another. Then take some pieces of woollen rag, and roll them up into a ball, covering them with a piece of. linen drawn tightly over. The rags inside should first be saturated with the polish, and the whole should be taken in the fingers of the right hand in such a way that the linen may be tightly drawn over, and may present to the wood a smooth rounded surface. Begin by polishing with free, circular strokes, and gradually traversing the whole surface. Apply now and then a drop of polish and a drop of oil to the surface of the rubber. When the grain of the wood disappears, allow it to stand for an hour or two till quite hard, and then glasspaper the whole as in varnishing. Repeat the process of polishing until the surface is quite smooth. If dull patches appear in the polish, they may be removed by a few drops of spirits of wine on a new rubber.

Polishing Black Woodwork.—(1) Procure 2½ oz. spirits of wine, 1 dr. oil of almonds, 1 dr. gum elemi, ½ oz. orange shellac, pounded fine and put together in a bottle to dissolve; when dissolved, rub on with white wadding. (2) Orange shellac, 2 oz.; wood naphtha, ½ pint; benzoin, 2 dr. Mix and put in warm place for a week, and keep the materials from settling by shaking it up. To apply it, after having prepared your wood by rubbing some raw linseed-oil into it, and then wiping it well off again, make a rubber of cotton-wool, and put some old calico over the face, and till you have a good body on your wood keep the rubber well saturated with polish. When your rubber sticks, put a very little linseed-oil on and rub your polish up. Allow it to stand a few

hours, and give it another coat, using rather more linseed-oil on your rubber, so as to get a finer polish. Then let it stand again and finish off with spirits of naphtha, if you can; if not, add a small quantity of polish to your spirit.

Polishing Deal.—To as much yellow ochre as you can take in your hand add ½ teaspoonful of Venetian red. Mix to the thickness of paint (or rather thinner) with glue size. Let the mixture simmer for some time in a pan, keeping it well stirred. Apply with a brush, and when dry run it over with fine sandpaper and polish with French polish, or, if preferred, turpentine and beeswax. If a deeper colour is required, add more Venetian red. Or melt about ¼ lb. Russian glue in 1 qt. water; grind in some Venetian red until sufficiently coloured; give the wood a coat with a brush when dry.

Egg-shell Polish for Antique Furniture.—This is done by first bodying-up your work, and, after standing 12 hours, again body-up with white polish; it is next rubbed down with a felt rubber and pumice until sufficiently dull; it is then wax-polished, giving the work a gloss instead of a polish.

Dry Shining.—This is a new system of polishing or shining called the American system, and is used mostly for American black walnut. First oil, fill in then with a wet rubber passed smartly over the work straight from end to end until a shine or gloss appears. No oil to be used in the rubber, and no spiriting-off is required. Be careful to dry rubber well, and to have the work free from rubber marks. This system is becoming very popular in the trade.

Imitation Polish for Woodwork.—The wood is first brushed over with gelatine, and, after drying and smoothing, varnished with a mixture of 2¼ lb. fluid copal varnish, and 4 dr. pure drying linseed-oil; after drying, the wood is polished with an ethereal solution of wax.

Wax Polishing.—(*a*) There is no particular art in wax-polishing floors, the principal requirements being plenty of elbow-grease and a good hard brush. The floor, after being well scrubbed, is allowed to dry. When dry it is painted over with a large, soft whitewash brush dipped in oak stain. This is allowed to dry for 24 hours. The floor is then gone over with thin size, and this is in turn allowed to dry for 24 hours. After this, the floor is painted over with a solution made by dissolving beeswax in spirits of turpentine, the proportions being about 1 lb. of wax to 2 qt. of turps. The wax is shredded, placed along with the turps in a stone bottle, and the whole put on the hob and frequently shaken. When this varnish has soaked well in, the whole floor is polished with a rather hard brush until a good surface is obtained. Special brushes, adapted to polishing waxed floors, are sold by oilmen. In dealing with large surfaces, it is as well to get the wax more deeply imbedded in the wood, and when a layer has been rubbed on, a hot iron, passed over it will melt the wax and drive it in. This gives far more body to polish on; the work is afterwards treated with more wax on the rubber, and then polished. (*b*) To wax floors. Melt 8 oz. rosin, then add 1 lb. beeswax. Mix together, and thin with turpentine. Apply it with a pad made of felt, and then polish well with a hard brush and soft clean rags. For dull wax polishing oak furniture try the following: Take raw linseed-oil, and give two coats, then apply the polishing paste composed of beeswax and turpentine; afterwards rub the furniture every day for a week. One of the best and cleanest methods of dealing with hard-wood floors, after they are once finished, is to simply rub them over every morning with a flannel cloth occasionally dipped in paraffin. The floor must be rubbed carefully with the grain of the wood, not crossways. Do not use any water.

Wood Finish.—Richness of effect

may be gained in decorative woodwork by using woods of different tone, such as amaranth and amboyna, by inlaying and veneering. The Hungarian ash and French walnut afford excellent veneers, especially the burls or gnarls. A few useful notes on the subject are given by a recent American authority. The polishes used can be toned down to match the wood, or be made to darken it, by the addition of colouring matters. The patented compositions known as "wood fillers" are made up in different colours for the purpose of preparing the surface of wood previous to the varnishing. They fill up the pores of the wood, rendering the surface hard and smooth. For polishing mahogany, walnut, etc., the following is recommended: Dissolve beeswax by heat in spirits of turpentine until the mixture becomes viscid; then apply by a clean cloth, and rub thoroughly with a flannel or cloth. A common mode of polishing mahogany is by rubbing it first with linseed-oil and then by a cloth dipped in very fine brickdust; a good gloss may also be produced by rubbing with linseed-oil, and then holding trimmings or shavings of the same material against the work in the lathe. Glasspaper, followed by rubbing, also gives a good lustre. ('Scient. Amer.')

A Good Polish for Walking-Sticks and other Hard Wood.—The following process gives the most satisfactory and hardest finished surface: fill with best clear filler or with shellac; dry by heat; rub down with pumice; then put on 3 coats of clear spirit copal varnish, hardening each in an oven at a temperature as hot as the wood and gum will safely stand. For extra work, the 2 first coats may be rubbed down and the last allowed a flowing coat. For coloured grounds, alcoholic shellac varnish with any suitable pigment (very finely ground in) can generally be used to advantage.

Polishing Dining Tables.—(1) Ordinary French polish will not withstand the heat of hot dishes. One of the best ways of treating the tops of dining tables is to first French polish it, then remove nearly all the polish by means of fine glasspaper, and finally polish with oil.

(2) Simmer about ½ pint linseed-oil over a slow fire for ¼ hour. Remove it from the fire, and add ½ gill of turpentine. Apply this mixture, and rub off with a soft rag. Do this once daily for a week, and a good dull polish will be obtained that will not be affected by hot dishes.

(3) Rub the table-top well down with pumice stone and water, then hand polish with boiled linseed-oil and tripoli powder, until a sufficiently bright surface is obtained. This takes time and labour, but the effect is very good.

Mother-of-Pearl.—Go over it with pumice finely powdered, washed to separate the impurities and dirt, with which polish it very smooth; then apply putty powder and water by a rubber, which will produce a fine gloss and good colour.

(2) Make a thick paste of finely ground rotten-stone with olive-oil, then add sufficient sulphuric acid to make it a thin cream. When the polish is applied, rub with a cork covered with velvet. When the polish on the shell is obtained, wash the shell well.

Shells.—(*a*) Marine shells are cleaned by rubbing with a rag dipped in common hydrochloric acid till the outer dull skin is removed, washing in warm water, drying in hot sawdust, and polishing with chamois leather. Those shells which have no natural polished surface may either be varnished or rubbed with a little tripoli powder and turpentine on wash-leather, then fine tripoli alone, and lastly with a little fine olive-oil, bringing up the surface with the chamois as before.

(*b*) The shells are first boiled in a strong solution of potash, then ground on wheels, sometimes through one stratum to show an underlying one, then polished with hydrochloric acid and putty powder. In this operation the hands are in great danger. Shell

grinders are generally almost cripples in their hands.

(c) Those selected to be preserved and polished may be roughly divided into three kinds. (1) Shells having a natural polish, or requiring very little preparation; (2) those which have no natural polish, but which may be polished without much trouble; (3) rough shells, requiring their roughness to be removed by mechanical means before they can be polished. Those in the first class need very little attention, especially when found with a glossy surface, and often of very beautiful variegated hues. Simply cleaning will answer with some of these; with others the colours and polish will not be so bright when dry as in a wet state, but the brightness can easily be restored by brushing them over with some liquid that dries with a more or less glossy surface. This might be water in which a little gum-arabic has been dissolved; or white of an egg, or colourless transparent varnish can be used. The last can of course be washed should the shells get dirty. With some, the polish and colours may be obscured by a dull epidermis, or outer skin; this must be removed by soaking in warm water, and rubbing it off with a brush or a rag dipped in common hydrochloric acid, afterwards well washing the shells in water, and proceeding as before. But after removing the dull skin, it will be found that most shells will have no natural polish; these constitute the second class. After removing the skin, wash well in warm water and dry in hot sawdust; then a polish may be induced by simply rubbing with chamois leather, or chamois leather and a little olive-oil. Some will probably require to be smoothed down with emery-paper, then rubbed with wash-leather dipped in turpentine and dressed with tripoli powder, then with fine tripoli alone, and finally with olive-oil and chamois leather for the finishing touches. Shells belonging to the third class are the most difficult, and take the longest time to polish; but these will be found to sub-divide themselves. Emery-cloth will remove the roughness of some, and they can then be polished as mentioned for the second class. Others must be ground with wheels of different degrees of fineness, or wooden and other discs dressed with different substances, such as washed emery, rotten-stone and water, and leather with putty-powder or tripoli. All rough shells should first be boiled in a strong solution of potash. When grinding some shells, the outer stratum or strata may be ground through, so as to show the underlying ones. Grinding shells is not an easy operation, and is oftentimes injurious to the hands.

Plaster Casts.—(a) Put into 4 lb. clear water 1 oz. pure curd soap, grated and dissolved in a well-glazed earthen vessel—then add 1 oz. white beeswax, cut into thin slices; when the whole is incorporated it is fit for use. Having well dried the figure before the fire, suspend it by a twine, and dip it once in the varnish; upon taking it out, the moisture will appear to have been absorbed in 2 minutes' time; stir the compost, and dip the figure a second time; this generally suffices. Cover it carefully from the dust for a week; then, with soft muslin rag, or cotton wool, rub the figure gently, when a most brilliant gloss will be produced.

(b) Take skimmed milk, and with a camel-hair pencil lay over the model till it will imbibe no more. Shake or blow off any that remains on the surface, and lay the figure in a place perfectly free from dust; when dry, it will look like polished marble. If the milk is not carefully skimmed, it will not answer the purpose.

(c) Fuse ½ oz. of tin, with the same quantity of bismuth, in a crucible; when melted add ½ oz. mercury; when perfectly combined, take the mixture from the fire and cool it. This substance, mixed with the white of an egg, forms a beautiful metallic varnish for plaster of Paris casts.

(d) Of stearine and Venetian soap each 2 parts; pearlash 1; the stearine

and soap cut small and mixed with with 30 parts solution of caustic potash, boiling for ½ hour, stirring continually. Add the pearlash dissolved in a little rainwater, and boil a few minutes; stir until cold, and mix with more lye until it is quite liquid; keep well covered up. Remove all dust and stains from the plaster, and apply the wash as long as it is absorbed. When dry, rub with a soft leather or brush. Should the surface not shine, apply another coat. This composition may be preserved for years.

(*e*) Coat with melted white wax, and place them before a fire until the wax is absorbed; a considerable polish can then be obtained by friction.

(*f*) First make very smooth and free from grit with glasspaper or otherwise; oil with linseed-oil; when dry, French polish in the usual way. If a bust, or anything similar, required to be white, make smooth, size with white size, and varnish with white hard varnish.

Vulcanite.—(*a*) Remove scratches with a smooth wet water-of-Ayr stone, and then polish in the lathe with fine pumice and a stiff brush. After washing the pumice off, polish it with whiting and soft brush.

(*b*) The mathematical instrument makers treat it as brass—that is, for flat work they first use water-of-Ayr stone, and then rotten-stone and oil. Turned work is polished in the lathe with rotten-stone and oil, taking care not to use too high a speed, which would heat the work. Some use lamp-black and oil to finish with where a very high polish is wanted, or the bare palm of the hand, as in getting up silver plate. Chain and ornament makers use circular buffs for their flat work, made of seahorse-leather, and for work of irregular forms, buffs of calico. A number of pieces of calico, 12 in. in diameter, are screwed together between flanges, like a circular-saw spindle, and used with rotten-stone, always taking care not to heat the work; brushes are not at all suitable for it.

(*c*) To polish turned vulcanite which has been finished with a scraping tool, take a handful of vulcanite shavings, and apply these as the article revolves. Next prepare a piece of soft linen (a surgical bandage will do) by soaking in any sort of common oil, and sprinkle one side with putty powder (oxide of tin), then loop the prepared side round the article, holding the ends firmly with both hands, and work it evenly all over the article while the lathe is running, and finish the polishing in the same manner with a clean piece of linen without polishing medium.

Celluloid.—Powdered pumice-stone applied on felt with plenty of water is suitable for smoothing celluloid after it has been emery-papered, but for polishing, whiting and water or putty powder and water should be used, finishing with a little dry whiting and then with a clean velvet pad.

Ivory, Horn, and Tortoise-shell.—Ivory and bone admit of being turned very smooth, or when filed may afterwards be scraped so as to present a good surface. They may be polished by rubbing first with fine glasspaper, and then with a piece of wet linen cloth dipped in powdered pumice. This will give a very fine surface, and the final polish may be produced by washed chalk or fine whiting applied by a piece of cloth wetted with soapsuds. Care must be taken in this, and in every instance where articles of different fineness are used, that, previous to applying a finer, every particle of the coarser material is removed, and that the rags are clean and free from grit. Ornamental work must be polished with the same materials as plain work, using brushes instead of linen, and rubbing as little as possible, otherwise the more prominent parts will be injured. The polishing material should be washed off with clean water, and when dry, may be rubbed with a clean brush.

Horn and tortoiseshell are so similar in their nature and texture that they may be classed together. As regards the general mode of working and polishing them, a very perfect surface

is given by scraping. The scraper may be made of a razor-blade, the edge of which should be rubbed upon an oil-stone, holding the blade nearly upright, so as to form an edge like that of a currier's knife, which may be sharpened by burnishing. Work when properly scraped is prepared for polishing. To effect this it is first rubbed with a buff made of woollen cloth perfectly free from grease. The cloth may be fixed upon a stick to be used by hand; but a "bob," which is a wheel running in the lathe and covered with the cloth, is much to be preferred on account of the rapidity of motion. The buff may be covered either with powdered charcoal and water, or fine brickdust and water. After the work has been made as smooth as possible with this, it is followed by another bob on which washed chalk or dry whiting is rubbed. The article to be polished is slightly moistened with vinegar, and the buff and whiting will produce a fine gloss, which may be completed by rubbing with the palm of the hand and a small portion of dry whiting or rotten-stone.

(*a*) Well scrape with glass or steel scraper, afterwards with finest glass-cloth, then with powdered bath brick and oil, and finally with rotten-stone and flannel, or old cloth or felt hat.

(*b*) First scrape with glass to take off any roughness, then grind some pumice to powder, and with a piece of cloth wetted and dipped in the powder, rub well until a smooth face is obtained. Next polish with rotten-stone and linseed-oil, and finish with dry flour and a piece of clean linen rag. The more rubbing with the stone and oil, the better the polish. Trent sand is used in the Sheffield factories. It is a very fine and sharp sand, and is prepared for use by calcining and sifting.

Marble.—(1) If the piece to be polished is a plane surface, it is first rubbed by means of another piece of marble, or hard stone, with the intervention of water and two sorts of sand: first with the finest river or drift sand, and then with common house or white sand, which latter leaves the surface sufficiently smooth for the process of gritting. Three sorts of grit stone are employed: first, Newcastle grit; second, a fine grit brought from the neighbourhood of Leeds; and lastly, a still finer, called snake grit, procured at Ayr, in Scotland. These are rubbed successively on the surface with water alone; by these means, the surface is gradually reduced to closeness of texture, fitting it for the process of glazing, which is performed by means of a wooden block having a thick piece of woollen stuff wound tightly round it. The interstices of the fibres of this are filled with prepared putty powder (peroxide of tin), and moistened with water; this being laid on the marble and loaded, and drawn up and down the marble by means of a handle, being occasionally wetted, until the desired gloss is produced. The polishing of mouldings is done with the same materials, but with rubbers varied in shape according to that of the moulding. The block is not used in this case; in its stead a piece of linen cloth is folded to make a handful; this also contains the putty powder and water. Sand rubbers employed to polish a slab of large dimensions should never exceed ⅓ of its length, nor ½ of its width; but if the piece of marble is small, it may be sanded itself on a larger piece of stone. The grit rubbers are never larger than that they may be easily held in one hand; the largest block is about 14 in. in length and 4½ in. in breadth.

(2) Polishing includes 5 operations. Smoothing the roughness left by the burin is done by rubbing the marble with a piece of moist sandstone; for mouldings, either wooden or iron mullers are used, crushed and wet sandstone, or sand, more or less fine according to the degree of polish required, being thrown under them. The second process is continued rubbing with pieces of pottery without enamel, which have only been baked once, also wet. If a brilliant polish is desired,

Gothland stone instead of pottery is used, and potters' clay or fullers' earth is placed beneath the muller. This operation is performed upon granites and porphyry with emery and a leaden muller, the upper part of which is incrusted with the mixture until reduced by friction to clay or an impalpable powder. As the polish depends almost entirely on these two operations, care must be taken that they are performed with a regular and steady movement. When the marble has received the first polish, the flaws, cavities, and soft spots are sought out and filled with mastic of a suitable colour. This mastic is usually composed of a mixture of yellow wax, rosin, and Burgundy pitch, mixed with a little sulphur and plaster passed through a fine sieve, which gives it the consistence of a thick paste; to colour this paste to a tone analogous to the ground tints or natural cement of the material upon which it is placed, lampblack and rouge, with a little of the prevailing colour of the material, are added. For green or red marbles, this mastic is sometimes made of lac, mixed with Spanish sealing-wax of the colour of the marble; it is applied hot with pincers, and these parts are polished with the rest. Sometimes crushed fragments of the marble worked are introduced into this cement; but for fine marbles the same colours are employed which are used in painting, and which will produce the same tone as the ground; the lac is added to give it body and brilliance. The third operation of polishing consists in rubbing it again with hard pumice, under which water is constantly poured, unmixed with sand. For the fourth process, called softening the ground, lead filings are mixed with the emery mud produced by the polishing of mirrors or the working of precious stones, and the marble is rubbed with a compact linen cushion, well saturated with this mixture; rouge is also used for this polish. For some outside works, and for hearths and paving tiles, marble workers confine themselves to this polish. When the marbles have holes or grains, a leaden muller is substituted for the linen cushion. In order to give a perfect brilliance to the polish, the gloss is applied. Well wash the prepared surfaces, and leave them until perfectly dry; then take a linen cushion, moistened only with water, and a little powder of calcined tin of the first quality. After rubbing with this for some time, take another cushion of dry rags, rub with it lightly, brush away any foreign substance which might scratch the marble, and a perfect polish will be obtained. A little alum mixed with the water used penetrates the pores of the marble, and gives it a speedier polish. This polish spots very easily, and is soon tarnished and destroyed by dampness. It is necessary, when purchasing articles of polished marbles, to subject them to the test of water; if there is too much alum, the marble absorbs the water, and a whitish spot is left.

(3) After using Robinhood or Hanhill grit, then the second grit, which is a little finer, and finishing with snake or water-of-Ayr stone, and great care having been given to get all scratches out with the second grit (pumice stone is equal to second grit on the edges), carefully snakestone off edges, arrises, and face. All that remains now is the important part of bossing up, to complete the shine or polish, which, with black marble, is a rather difficult job for a novice. Get some fine emery powder, a small quantity of spirits of salts, putty powder, oxalic acid, salts of sorrel, and some felt. For white marble proceed as follows: Crush to powder the oxalic acid and salts of sorrel, and put each in a separate tin having a few holes in the lid. Cut up the felt to form a pad or boss. Sprinkle some oxalic acid on the boss with a little water to moisten it, and rub the marble until a glimmer appears. Afterwards wash the marble well, and cut another pad, or wash the other well out. Repeat the process with salts of sorrel with a little putty powder added, rubbing

until the marble is sufficiently brilliant. Wash off and rub a little soap (on sponge) on the marble to take acids off, and the job is finished. Care should be taken not to let the pad or boss project too far over the sides of the marble when rubbing, or the acid will burn the skin off the edges. The acid that forms along the edges after a few rubs should be taken off. For black marble, get a piece of clean sacking, sprinkle a little emery powder, moisten with water, and rub on the marble until it is dry, when, if the gritting has been properly done, a glimmer will appear. Obtain as much shine as possible with this. Then pour a small quantity of spirits of salts into an egg-cup and sprinkle in some putty powder until the spirit is nearly soaked up. Make a boss out of a piece of old cotton stocking, and rub a little spirits and putty on the boss, adding a little water to moisten. Great care must now be observed, as a little too much of spirits and putty will burn off the polish that is already on, and render it necessary for the marble to be second-gritted and snake-stoned over again. A good shine can be obtained with spirits and putty sufficient to complete. However, if this finishes dull, a little powdered borax rubbed dry on the marble with a stocking boss is an advantage. There are, of course, other ways of polishing marble, but most of them are too intricate for a novice.

Slate.—Slate is faced first with an iron plate with river sand and water, smoothed with pumice, then japanned and baked to harden the japan, and again smoothed with pumice and polished with rotten-stone.

Pebbles.—Pebbles may be cut and polished by an amateur, an old sewing machine serving as the basis of a cutting machine; but in place of the ordinary wheel it would be necessary to put a heavy fly-wheel, say of about 18 lb. weight and about 12 in. in diameter, with a pulley about 7 in. in diameter attached. On the table should be screwed two wooden blocks with bearings for a 1-in. iron pipe, to which should be attached a pulley about 4 in. in diameter, and two nuts for bolting on the cutting and polishing discs. Let the cutting discs be of thick copper about 4 in. in diameter, bevelled at the edges, and fed with emery and water. The polishing discs will be one of copper (about 6 in. in diameter), using fine sand and water, one of wood, using crocus and water, one of wood covered with leather and whiting, and one of wood covered with felt and dry putty powder (peroxide of tin).

Diamond Cutting and Polishing.—The first process is what is called "cutting" the stone—albeit this cutting is really rubbing. When in its rough state, the stone presents a rugged appearance, shapeless, and full of sharp angularities. It is the cutter's work to reduce the indefinable pebble to something like shape and form, and thus render the work of polishing easier and more expeditious. Should the diamond possess flaws—that is, spots which militate against its commercial value—recourse is had to cleaving, in which operation these flaws are removed without decreasing to any considerable extent the size or value of the stone. Cleaving is effected by means of a small knife tapped lightly with a hammer. To successfully cleave a diamond the utmost care is necessary, and the cleaver must be thoroughly acquainted with the fibre of the stone.

To an outsider there is no such thing as a fibre to a diamond; to the cleaver there is, and unless the knife is placed in one certain position the whole stone is likely to be spoilt. The diamond is, by means of a certain kind of cement, which rapidly hardens when cooling, fixed to the end of a stick termed the "snyder's or cutter's stock (Fig. 155). This stock is fastened in a sort of vice, and the cleaver, placing

FIG. 155.

his knife on the edge containing the flaw, gives it a gentle tap with a hammer, and the piece is at once

divided in a similar way to the cleaving of slate.

But it is only when a stone contains these flaws that cleaving is resorted to, so that practically the first operation is that of cutting. This is effected by placing two stones to be cut each in a snyder's stock, as before described, with the rough edges of the stone to be cut so fixed that the edge of the one may easily be rubbed against the edge of the other. This is very laborious and tiring work, and the cutter is compelled to wear thick leather gloves. Even this precaution does not prevent the rapid growth of corns on the hands and fingers.

The rubbing is done over a small brass box A (Fig. 156), which has a double bottom, the one above being pierced with numberless minute holes, through which the powder as deposited from the rubbing falls into the lower box. This powder is carefully preserved, and, mixed with the finest Lucca oil in the proportion of 30 drops of oil to the carat of powder, is afterwards used to polish the stones. In order to facilitate the work, the cutter rests the two stocks against two pins, which act as a sort of fulcrum.

FIG. 156.

When all the rugged irregularities of form have been removed by the cutter, the stone is handed to another workman, who proceeds to fix it by means of molten lead in an instrument called the "dop," which is in form similar to the acorn. To the cup is attached a length of thick but remarkably pliable copper wire, specially prepared in Holland for this purpose (Fig. 157). The cup being filled with lead, the diamond is inserted at the apex of the little mound of lead in the position required by the polisher. The height and size of the mould depends upon the nature of the stone, some requiring a high and well-defined apex, others almost a globe. The dop is handed to the polisher, who proceeds to place it in the tongue (Fig. 158).

FIG. 157.

The wheel upon which the stones are polished or ground is the ordinary lapidary's wheel, but much more care is required in its preparation. There is a class of workmen who do nothing else but prepare the wheels for the polisher. A large variety of stones are required to reduce the surface of the wheel to the requisite fineness, and all these stones are imported, as well as everything else connected with the trade, from Holland. In fixing the wheels, the most perfect balance is required, as the slightest vibration may destroy a diamond. The wheel is turned very rapidly. The tongue is fixed by means of two iron uprights in its proper position, and the surface of the diamond to be polished is kept pressing against the rotary wheel by means of a leaden weight placed on the broad surface of the tongue (Fig. 158).

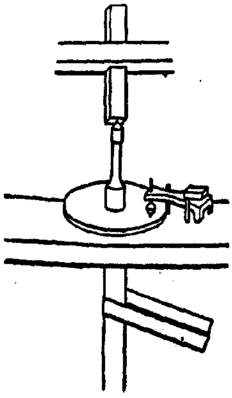


FIG. 158.

Before setting the stone on the wheel, the polisher applies to the diamond a small drop of diamond powder and oil well mixed. The dust procured by the cutting is never sufficient for the polisher's use; consequently stones of a very inferior quality, and of no com-

mercial value as gems, are first ground to powder in the "meteer" or grinder (Fig. 159). This consists of a metal mortar B and a ramrod-like pestle A, which, when worked up and down in the same way as a churn, gradually reduces the stones to powder. The powder is thoroughly incorporated with the oil, and presents a thick black sticky appearance. But the powder, owing to its heavy weight, sinks rapidly, and it is only by constant stirring that the mixture is kept ready for use.

FIG. 159.

The dop is so placed on the wheel that the part to be polished comes directly in contact with its surface. The revolving wheel gradually—very gradually indeed—wears away the surface in contact with it, and the polisher must use his judgment as to the size and form of the facet he wishes to produce, which, of course, depends upon the size of the stone. In all, the stone has to be polished on 62 surfaces—that is, there are on the largest as well on the smallest diamond 62 facets. The facets are known as the table or top, the cutlet or bottom, hooks or corners, sides, ends, end facets, and verstelletje or stars.

The wheel, or, as it is termed in Dutch, the "skyf," has to be continually repolished and ground, for although the wheel grinds the diamond, the diamond *en révanche* grinds the wheel, consequently, in time, the surface of the plate is reduced to uneven rings. As a rule, a polisher has four stones in hand at once, and great care is taken in keeping the stones perfectly cool. The period of completion varies with the size of the diamond, some large stones taking weeks to polish. But the same care must be taken with small as with large stones. As no two stones are precisely of the same dimensions, it follows that the sizes of the facets also vary.

It will be seen what care and judgment are required in polishing each surface to its requisite shape, size, and angle. The utmost care and skill are also required in placing the dop to its exact angle, so that the skyf produces the proper facet. In fact, in each branch of the trade every workman must be, and is, well up in his work. Thus the lads who fill in the dops with lead, handle with their naked fingers, with the utmost *sang froid*, the hot metal while even in a soft condition. The dust produced by the action of the wheel closely resembles soot—in fact, it is nothing but carbon. When the stone leaves the polisher's hands it is a bright, glowing sparkling gem, and only requires setting in the article it is intended for.

Metals.—The polishing of metals differs according to their kind, but there are some general principles common to all, of which it may be useful to have a clear idea. All polishing is begun in the first instance by rubbing down the surface by some hard substance that will produce a number of scratches in all directions, the level of which is nearly the same, and which obliterate the marks of the file, scraper, or turning tool that has been first employed. For this purpose coarse emery is used, or pumice and water, or sand and water, applied upon a piece of soft wood, or of felt, skin, or similar material. When the first coarse marks have been thus removed, next proceed to remove the marks left by the pumice by finely-powdered pumice ground up with olive-oil, or by finer emery and oil. In some cases certain polishing stones are employed, as a kind of hard slate used with water. To proceed with the polishing, still finer powders are used, such as tripoli and rotten-stone. Putty of tin and crocus martis are also used for high degrees of polish. But the whole process consists merely in removing coarse scratches by substituting those which are finer and finer, until they are no longer visible to the naked eye; and even long after that, if the surface is examined by a microscope, it will be seen that what appeared without any scratches is covered all

over with an infinity of them, but so minute that they require a high magnifier to be discovered. It is evident that great care must be taken to have the last polishing material uniformly fine, for a single grain or two of any coarse substance mixed with it will produce some visible scratches instead of a perfectly polished surface.

Brass.—(*a*) Brass may be polished without a burnisher, by using an exceedingly fine cut file, and fine emery cloth.

(*b*) Small articles to be polished should be shaken by themselves for a short time; then some greasy parings of leather should be put in with them. After they have been shaken smooth, the greasy leather parings should be removed and clean ones put in, and the shaking continued until the articles are sufficiently bright.

(*c*) When the brass is made smooth by turning or filing with a very fine file, it may be rubbed with a smooth fine-grained stone, or with charcoal and water. When it is made quite smooth and free from scratches, it may be polished with rotten-stone and oil, alcohol, or spirits of turpentine.

German Silver.—Take 1 lb. iron peroxide, pure, and put half of it into a wash-basin, pouring on water, and keeping it stirred until the basin is nearly full. While the water and crocus is in slow motion, pour off, leaving grit at the bottom. Repeat this a second time, pouring off with another basin. Cleanse out grit, and do the same with the other half. When the second lot is poured off, the crocus in the first will have settled to the bottom; pour off the water gently, take out the powder and dry it, and put both, when washed clear of grit, and dried, into a box into which dust cannot get. If the work is very dirty, rub a mixture of powder and oil on with the fingers, and then it will be known if any grit is on the work. If the work is not very black, take a piece of soft chamois leather, and rub some dry crocus on, and when well-rubbed, shake out the leather, and let the powder fall off that is not used, or rub it off with a brush. Do not put down the leather in the dust.

Iron and Steel.—(*a*) Take an ordinary bar of wrought iron in its usual merchantable state, remove the oxide from its surface by the application of diluted sulphuric acid, after which wash the bar in an alkaline solution, then cover the entire bar with oil or petroleum. The bar is then ready for the chief process. A muffle furnace is so prepared that a uniform, or nearly uniform, heat can be maintained within it, and in this furnace the bar is placed. Care must be taken that too great a heat is not imparted to it, for on this depends the success of the operation. When the bar approaches a red heat, and when the redness is just perceptible, it is a certain indication that the proper degree of heat has been attained. The bar is then at once to be removed, and passed through the finishing rolls five or six times, when it will be found to have a dark polished uniform surface, and appearance of Russian sheet iron.

(*b*) A good polish for iron or steel rotating in the lathe, is made of fine emery and oil; which is applied by lead or wood grinders, screwed together. Three very good oils for lubrication are olive-oil, sperm, and neat's foot.

(*c*) Use bell-metal polishers for arbors, having first brought up the surface with oilstone dust and oil and soft steel polishers; for flat pieces use a piece of glass for the oilstone dust, and a bell-metal block for the sharp red stuff, and a white metal block for the fine red stuff. The polishing stuff must be well-mixed up and kept very clean; the polishers and blocks must be filed to clean off the old stuff, and then rubbed over with soft bread; put only a little red stuff on the block and keep working it until it is quite dry; the piece will then leave the block quite clean; use bread to clean off the surplus red stuff before using the brush. If the piece is scratched, put on some more red stuff,

which must not be too wet, and try again.

(*d*) The polish on flat steel pieces in fine watchwork is produced with oilstone dust, burnt Turkey stone, and a steel polisher, soft steel, bell-metal, and sharp stuff, grain tin and glossing stuff. The metals are squared with a file, and vary in shape according to the work in hand.

(*e*) Get an 18-gal. barrel and put an iron spindle through the two ends; mount it on trestles in the same way as a butter churn, with a winch to turn it by; cut out a hole in the side by which to introduce the articles to be polished; have a tight-fitting cover to the hole; procure some worn-out casting pots or crucibles, such as used by casters, and pound them in an iron mortar, until fine enough to pass through a sieve which will not allow the steel articles to pass through. Put equal quantities of this grit and of the articles in the barrel; fasten on the cover, and turn the barrel for about an hour, at the rate of about 50 turns a minute; take all out of the barrel and sift out the grit. If a finer polish than this is required, put them through another turning, substituting for the grit small scraps of leather, called mosings, which can be procured from the curriers, and emery flour. Do not more than half fill the barrel.

Wheel-Polishing.—To afford a high lustre to metallic articles, substances are used which, though they attack the articles very delicately, possess sufficient hardness to remove the scratches and roughness produced by grinding with emery, pumice, etc. These are called "polishing agents" or, as they are always used in a powdered form, "polishing powders," the most important of them being lime, ferric oxide (crocus and rouge), tripoli, tin-putty, chalk and graphite.

For the proper use of these powders they are generally mixed with a fluid, water, spirits of wine or oil being used for the purpose. With these fluids the polishing agents are made into a paste. Smooth articles which can be secured in the lathe are polished by pressing the tool provided with the polishing agent against the revolving article. In this case flexible pieces of leather or cloth can be used, or sticks of wood covered with leather or cloth. These tools are called "polishing files." By joining two of them together by a hinge-joint the "polishing stock" is formed, which is used for polishing smooth bodies in the lathe.

In polishing, as well as in grinding, it is necessary that either the work or the tool move with great velocity, therefore disk-like tools are generally used, which are secured either in a lathe or a lathe-like machine, which allows of a still more rapid revolution of the disks than the lathe. These disks are commonly known as buff-wheels, one variety of them consisting of a wooden disk covered with walrus leather.

The final dead grinding is also executed with such polishing disks. For this purpose very finely elutriated emery is uniformly applied to the leather of the polishing wheel. When dry a second and third application of emery may, if necessary, be made. This disk is called the "roughing wheel," and when somewhat worn it is termed "medium wheel," and when almost completely denuded of grinding agent "fine wheel." In grinding with these wheels, oil is used. When the grinding agent is used up the remainder is soaked with warm water and scraped off with a knife to prepare the disk for a fresh application. In consequence of the rapid rotation of the disk the leather and the layer of emery become brittle and full of fissures. To remove this defect a piece of tallow is held against the revolving disk, and it is then smoothed by pressing a smooth stone against it. For polishing, the polishing agent mixed with oil is applied to the clean leather of the disk. (See also POLISHING WHEELS.)

Scratch-Brushing.—When articles in relief have to be brightened the polishing wheel is not easily employed,

nor is the burnisher always a convenient tool. Scratch-brushing is more often resorted to, this being a brush in which the bristles are replaced by wires. Hard brass wire is commonly used, though not always. These brushes may be circular to be operated by a lathe, as Fig. 160, or they may be hand brushes, as Fig. 161. To make a

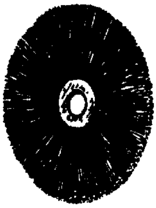


FIG. 160.

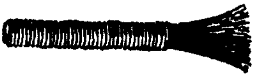


FIG. 161.

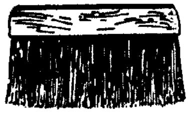


FIG. 162.

hand scratch-brush, take a coil of the wire, of suitable fineness, and let this coil be as large as possible that the curve of the cut wire will not be great. A little curve is better than a quite straight wire, but it must not be too pronounced. Having the coil of wire ready, do not uncoil it, but bind it tightly round with strong string for about two-thirds the intended length of the brush—say 6–8 in. Now take a chisel and cut through the bunch of wire close to the string binding, at one end, and about 2 in. from the string at the other end. Having done this solder over the end of the bunch where it is cut near the string, so as to secure the wires together, and make the end smooth to the hand. If desired a wooden handle can be bound to the brush, or it may be used as it is. When a scratch-brush is worn so that the wires bend out in all directions like a mop, it can have a long handle affixed and then be useful for scouring out vases and hollow goods. For use on large surfaces a brush as Fig. 162 may be made, this is used for flat plate work.

In using the scratch-brush it is not usually applied dry, the tool as well as the pieces must be constantly wet with fluids, especially such as produce a foam in brushing, for instance, water and vinegar, or sour wine, or solutions of cream of tartar or alum, when it is desired to brighten a gold deposit which is too dark; but that most generally used is a decoction of licorice-root, of horse-chestnut, of marsh-mallow, of soap-wort, or of the bark of Panama-wood, all of which being slightly mucilaginous, allow of a gentle scouring with the scratch-brush, with the production of an abundant froth. A good adjunct for scratch-brushing is a shallow wooden tub containing the solution employed, with a board laid across it, nearly level with the edges, which, however, project a little above. This serves as a rest for the articles.

When scratch-brushing small articles and jewellery the operator holds the scratch-brush as he would a writing-pen, and moves it over the article with a back-and-forward motion imparted by the wrist only, the forearm resting on the edge of the tub. For larger articles, on the contrary, the operator holds his extended fingers close to the lower part of the scratch-brush, so as to give the wires a certain support, and, with raised elbow, strikes the piece repeatedly, at the same time giving the tool a sliding motion. When a hollow is met with which cannot be

scoured longitudinally, a twisting motion is given to the brush.

Brushes like Fig. 160 are used perhaps to a greater extent than any other, for plated goods of most kinds may be treated with a wheel-brush. The top of the brush revolves towards the operator, who presents the object to be scratched to the bottom. The brush is surrounded by a wooden cage or screen to prevent splashing. It is open in front, and above it is placed a reservoir of one of the liquids above named, from which a slender jet of the liquid is allowed to dribble upon the top of the brush. In order to protect the operator against the water projected by the rapid motion, there is fixed to the top of the frame a small inclined board, which reaches a little lower than the axis of the brush, without touching it. This board receives the projected liquid and lets it fall into a zinc trough which forms the bottom of the box, whence a tube conveys away the waste liquor to a pail beneath.

Hand and lathe scratch-brushes are made of wire of various gauges, from coarse to very fine, according to their intended uses. Scratch-brushes of spun glass, with fibres of extreme fineness and elasticity, are also used for scouring very delicate objects.

When a hand scratch-brush becomes worn, the bent ends are cut off with a cold chisel, and a new portion of wire is uncovered by removing part of the string-wrapping. The best way to remove the bent wire ends is to rest the scratch-brush upon a lead block, and cut the ends off with a sharp cold chisel, if possible with one stroke of the hammer. Scratch-brushes must be carefully looked after and their wires kept in good order. When they begin to curl, they may be now and then beaten with a mallet.

Polishing Powders and Materials.—*Plate Cleaning Powders and Materials.*—(*a*) Take equal parts of precipitated subcarbonate of iron and prepared chalk.

(*b*) An impalpable rouge may be prepared by calcining iron oxalate.

(*c*) Take quicksilver with chalk, ½ oz., and prepared chalk, 2 oz., mix them. When used, add a small quantity of spirit of wine, and rub with chamois leather.

(*d*) Put iron sulphate into a large tobacco pipe, and place it in a fire for ½ hour; mix with a small quantity of powdered chalk. This powder should be used dry.

(*e*) For jewellers. Take 10 parts of jewellers' rouge and add 60 parts carbonate of magnesia. For use moisten with methylated spirits (alcohol).

(*f*) For silver plate. Take 20 grains of argentic nitrate and 1 oz. potassic cyanide, and dissolve them in rather less than ½ pint of water. Apply with a soft brush and then rub off with a cloth followed by a leather.

(*g*) For silver plate. Petroleum or paraffin oil will loosen dirt and discoloration on silver surfaces very rapidly, but the goods must be well washed and polished with plenty of whiting to remove all traces of the oil and odour.

(*h*) For urns. Salt ground to flour 1 oz., finest flour emery 1 oz., powdered pipeclay 3 oz., putty powder (oxide of tin) 3 oz., powdered rottenstone ½ lb., Paris white ½ lb. Mix or grind together and sift.

(*i*) For general purposes. Red oxide of iron 3 parts, chalk (washed) 2 parts, carbonate of magnesia 2 parts. Grind or mix together and sift several times.

(*j*) White rouge. Powdered tartaric acid 1 part, precipitated silica 11 parts. Mix and sift well.

(*k*) 4 parts powdered soda, 40 parts fine whiting, 1 part powdered citric acid. Moisten with water for use, the acid and soda then being dissolved and acting chemically on the dirt.

Parisian Polishing Powder.—This has been introduced and had a large demand. It is an attractive rose colour and is suited for gold, silver, or baser metals. It consists merely of 12 parts of carbonate of magnesia and 2 parts of jewellers' rouge. Water or spirits can be used to apply it with.

Belgian Polishing Powder.—This is

recommended chiefly for silver ware. Fine whiting 25 parts, washed pipe-clay 11 parts, dry white-lead 6 parts, white magnesia 2 parts, jewellers' rouge 2 parts.

Magic Polish.—This is chiefly used for brass. Mix in ¾ lb. of water, ¼ lb. of sulphuric acid and ¼ lb. powdered bichromate of potash. Apply the liquid freely to the metal, afterwards wash in plenty of water, wipe dry, and polish with crocus or rotten-stone.

Polishing Cloths.—These are made by soaking pieces of linen or damask in a liquid composed of polishing ingredients then drying them.

(*a*) Take, by weight, 4 parts of Castile soap, 2 parts of tripoli, and dissolve in 20 parts of water. Soak the cloths in this, and then dry.

(*b*) Boil 1 oz. of hartshorn powder in ½ pint of water; soak the cloths in this, and dry. This is an effective preparation.

(*c*) For flannel cloths. Make a solution of 2 parts of dextrin, 2 parts logwood decoction, 3 parts of oxalic acid, and dip the flannel in this. Wring gently, then sift over them a mixture of tripoli and pumice-stone, both finely powdered. Lay the moist powdered cloths on top of one another and apply pressure. Afterwards take apart and dry.

Polishing Soaps.—(*a*) Ordinary silver soap. Dissolve 1 lb. pure Castile soap in 1 lb. of soft water by heat. When this soap paste is ready remove it from the fire and add 3 lb. of fine whiting. Mix well and put into moulds to cool.

(*b*) Rose colour. Proceed as just described, but let rouge take the place of a part of the whiting.

(*c*) Rose colour. Make a soap paste as just described, and when ready add 1 lb. of finest white tripoli, 1½ lb. washed chalk, and ½ lb. rouge. A few drops of oil of lavender may be added, this being a good quality soap.

(*d*) Mix 3 oz. of turpentine in ½ lb. water, and boil 1 lb. of good hard soap in this until quite dissolved. Add 6 oz. liquid ammonia and put to cool.

Polishing Pastes.—(*a*) 6 parts vaseline, 10 parts fine whiting, 2 parts hartshorn powder, 2 parts powdered cuttle-bone. This should be of the consistency of lard and is packed in tins. A few drops of oil of lavender or of nitrobenzol will afford perfume.

(*b*) For brass. Dissolve 15 parts of oxalic acid in 120 of boiling water, and add 500 parts of pumice powder, 7 of oil of turpentine, 60 of soft soap, and 65 of any kind of fat oil.

(*c*) Soft soap 1 lb., powdered rotten-stone 2 lb. Mix.

(*d*) 5 lb. lard or vaseline. Melt, and stir in 1 lb. fine crocus or rouge.

(*e*) 2 lb. palm oil, 2 lb. vaseline. Melt, and stir in 1 lb. crocus, ¾ lb. tripoli, and ¾ oz. of oxalic acid.

(*f*) 4 lb. petroleum, 1 lb. lard. Melt together, and stir in 5 lb. crocus or rouge.

All the foregoing would be packed in tins and can be perfumed as described with (*a*).

(*g*) 50 parts of infusorial earth, 10 parts flour emery, brought to a suitable consistence with soap solution, which is hard soap dissolved in spirits of wine.

Putty Powder or Oxide of Tin.—Metallic tin is dissolved in nitro-muriatic acid, and precipitated from the filtered solution by liquid ammonia, both fluids being largely diluted with water. The tin peroxide is then washed in abundance of water. Collect in a cloth filter, and squeeze as dry as possible in a piece of new linen. The mass is now subjected to pressure in a screw press, or between two lever boards, to make it as dry as possible. When the lump thus produced has been broken, it is placed in a crucible, and closely covered up to prevent jets from entering, and is then exposed and heated to a white heat, and ground for use in the usual way; this oxide is used specially for cements, and polishing astronomical object-glasses for astro-telescopes. The putty powder of commerce, if of good fair quality, is alloyed with about equal parts of

tin and lead, which answers for ordinary purposes, but not for polishing lenses, in which good work is wholly dependent on the quality of the powder.

Crocus and Rouge.—The rouge used by machinists, watchmakers, and jewellers is a mineral substance. In its preparation, crystals of iron sulphate, commonly known as copperas, are heated in iron pots, by which the sulphuric acid is expelled and the oxide of iron remains. Those portions least calcined, when ground, are used for polishing gold and silver. These are of a bright crimson colour. The darker and more calcined portions are known as crocus, and are used for polishing brass and steel. For the finishing process for the specula of telescopes usually made of iron or of steel, crocus is invaluable: it gives a splendid polish. Others prefer for the production of rouge the peroxide of iron precipitated by ammonia from a dilute solution of iron sulphate, which is washed, compressed until dry, then exposed to a low red heat and ground to powder.

Jewellers' Rouge.—A rouge suitable for fine work may be made by decomposing a solution of iron sulphate with oxalic acid also in solution; a precipitate of iron oxalate falls, which must be well washed and dried; when gently heated, the salt takes fire, leaving an impalpable powder of iron oxide.

Furniture Creams, Pastes, and Oils.—*Furniture Creams.*—(*a*) Yellow wax, 4 oz.; yellow soap, 2 oz.; water, 50 oz.; boil with constant stirring, and add boiled oil and oil of turpentine, each 5 oz.

(*b*) Soft water, 1 gal.; soap, 4 oz.; white wax, in shavings, 1 lb. Boil together, and add 2 oz. pearlash. To be diluted with water, laid on with a paint brush, and polished off with a hard brush or cloth.

(*c*) Wax, 3 oz.; pearlash, 2 oz.; water, 6 oz. Heat together, and add 4 oz. boiled oil and 5 oz. spirits of turpentine.

(*d*) Raw linseed-oil, 6 oz.; white wine vinegar, 3 oz.; methylated spirit, 3 oz.; butter of antimony, ½ oz.; mix the linseed-oil with the vinegar by degrees, and shake well so as to prevent separation; add the spirit and antimony, and mix thoroughly.

Polish for Reviving Old Furniture. Take alcohol 3 oz.; spirits of salts (muriatic acid) 1 oz.; linseed-oil 1 lb.; best vinegar 1 pint; and butter of antimony 3 oz.: mix, putting in the vinegar last.

This is an excellent reviver, making furniture look nearly equal to new, and really giving a polish to new work. Shake it as used. If butter of antimony is not obtainable, the following will be the next best thing:—

Polish for Removing Stains, Spots, and Mildew from Furniture.—Take of 98 per cent. alcohol 1 pint; pulverised rosin and gum shellac, of each ¼ oz. Let these be cut in the alcohol; then add linseed-oil 1 pint: shake well, and apply with a sponge, brush, cotton, or flannel, rubbing it well after the application, which gives a nice polish.

These are useful polishes for new furniture when sold and about to be taken out of the shop; removing the dust and giving the new appearance again.

Furniture Pastes.—(*a*) To keep wood light, scrape ¼ lb. beeswax into ½ pint turpentine. By adding linseed-oil the wood is darkened.

(*b*) Dissolve 6 oz. pearlash in 1 qt. hot water, add ½ lb. white wax, and simmer for ½ hour in a pipkin; take from off the fire; when cool the wax will float; it should be taken off, and, with a little hot water, worked into a paste.

(*c*) Beeswax, spirits of turpentine, and linseed-oil, equal parts; melt and cool.

(*d*) Beeswax, 4 oz.; turpentine, 10 oz.; alkanet root to colour, melt, and strain.

(*e*) Digest 2 dr. alkanet root in 20 oz. turpentine till the colour is imparted; add yellow wax in shavings, 4 oz.; place on a water-bath, and stir till the mixture is complete.

(*f*) Beeswax, 1 lb.; linseed-oil, 5 oz.; alkanet root, ½ oz.: melt, add 5 oz. turpentine, strain, and cool.

(*g*) Beeswax, 4 oz.; rosin, 1 oz.; oil of turpentine, 2 oz.; Venetian red to colour.

(*h*) 1 lb. white wax; 1 oz. black rosin; 1 oz. alkanet root; and 10 oz. linseed-oil.

Furniture Oils.—(*a*) Boiled linseed-oil, 1 pint; yellow wax, 4 oz.; melt, and colour with alkanet root.

(*b*) Acetic acid, 2 dr.; oil of lavender, ½ dr.; rectified spirit, 1 dr.; linseed-oil, 4 oz.

(*c*) Linseed-oil, 1 pint; alkanet root, 2 oz.; heat, strain, and add lac varnish, 1 oz.

(*d*) Linseed-oil, 1 pint; rectified spirit, 2 oz.; butter of antimony, 4 oz.

(*e*) For darkening furniture, 1 pint linseed-oil; 1 oz. rose-pink; and 1 oz. alkanet root, beaten up in a metal mortar; let the mixture stand for a day or two; then pour off the oil, which will be found of a rich colour.

(*f*) Mix 2 oz. alkanet root with 4 oz. shellac varnish, 2 oz. turpentine, the same quantity of scraped beeswax, and 1 pint linseed-oil; this should stand a week.

(*g*) 1 part, by weight, linseed-oil; 7½ parts ether; 10 parts rectified oil of turpentine; 10 parts benzine. Mix, apply with flannel. This can be coloured, if desired, with turmeric, alkanet, annatto, etc.

(*h*) An oil mixture the writer has used for years with every satisfaction consists of ¼ pint turpentine; ¼ pint vinegar; and ½ pint raw linseed-oil. Mixed and kept in a bottle. Shake before using. This goes to the colour and consistence of thin yellowish cream.

Knife Polish.—Flour emery 1 part, powdered bathbrick 5 parts, powdered crocus (the middle purple oxide of iron) 1 part.

Window Glass Polish.—(*a*) An egg-cup of paraffin oil in the pail of water used for washing windows, gives a brilliant finish. (*b*) Calcined magnesia, 10 parts; cream of tartar, 12 parts; fine whiting, 56 parts; starch powder, 14 parts; precipitated silica, 16 parts. Grind finely, and mix well. When required for use take a portion and make it a thin cream with benzoline (which is best) or water. Apply with one rag and wipe off with another.

Stove Polish.—Mix together, in powdered form, 4 parts of green sulphate of iron, 2 parts bone black, and 2 parts of plumbago (black lead). For use add water to make a thin paste.

Stove Paste.—Mix finely-ground plumbago (black lead) with sufficient silicate of soda to make a smooth paste. Add ¼ lb. glycerine to each 4 lb. of paste. To obtain a more intense black a little aniline black can be added.

POLISHING-WHEELS.

Emery Wheels.—(*a*) Can be made with shellac powdered fine, and a small portion of rosin, a piece about the size of a walnut to 1 oz. shellac, and a piece of old vulcanised rubber about the same size, which gives it toughness. Shellac about 1 oz. to 1 lb. of emery, well melt, and stir about in a small iron pan; well mix the powders before applying heat. Be careful not to burn it, or get grease in it; have a ring of iron and a piece of plate iron prepared with black-lead and beer pretty thick; place the ring upon the plate and make a mould, turn the stuff into it, and well ram down evenly; put on one side to cool; when cold, turn out and chuck in lathe, and with a piece of red-hot iron bore a hole for spindle; after spindled put between centres, and trice-up with hot iron. Very good grindstones may be made with silver-sand mixed with powdered glass, and it is necessary to have some body besides shellac for coarse emery to form a body to bed the grains in. Emery dust from grinding glass, and Turkey-stone slips, and slate, may be used as a substitute for the flour emery.

(*b*) The best emery wheels are formed of the clean emery compounded with just a sufficient amount of boiled linseed-oil, the mixture being agitated for a sufficient period under exposure to a considerable temperature and a free access of atmospheric air, or some still more powerful oxidising agent; it assumes the necessary degree of tenacity, and whilst warm, being exposed to hydraulic pressure in a suitable mould, and subsequent drying in a stove, the emery wheel is complete.

(*c*) An emery wheel probably does more work and has less care taken of it than any tool of its size in the shop. Made of fine particles of emery, corundum, or carborundum, which are held together by a bond of some kind and baked at a high temperature, it becomes a revolving tool of many cutting edges. In some makes the bond is also of a material having abrasive properties, which is a valuable feature. Emery wheels are usually considered very brittle articles, but that is not necessarily the case.

A few years ago we heard of many more wheels bursting than we do now. The strain on a wheel at high speed is considerable, and it is not advisable to run a wheel faster than builders recommend. It is to their interest to advocate the fastest speed which is safe, as the wheels do better work. A surface speed of 5000 ft. a minute gives a strain of 75 lb. per square inch to the wheel, and as this increases as the square of the speed, the strain comes up very rapidly. At 10,000 revolutions this would be 4 times 75, or 300 lb. per square inch, which is more than most wheels will stand. Keep them at about 5000 ft., or nearly a mile a minute, and you get good results.

The method of mounting has much to do with the breaking of emery wheels, and a few suggestions are in order.

Never crowd an emery wheel on the arbor. It should always be an easy fit, so that if the arbor expands from heating of bearings it will not burst the wheel.

Always use a good-sized flange—at least one-third the diameter of wheel, and half is better. The side next to wheel should be concave — never straight or convex. A concave flange grips the wheel firmly nearer the outside, and drives better, as well as tending to prevent breakage. Some mount wheels with only a small nut, and possibly a washer under it. This practice is liable to break wheels.

Grinding machines should be heavy, and bolted to the foundation. Cast iron is cheap, and it pays to use it here, as a heavy machine does better grinding.

Keep your rests in good order if you use them. They should be kept close to wheel, as probably more wheels are broken by work getting caught between

wheel and rest than in any other way. Caliper rests are perhaps the best, as they can be kept close to the sides of the wheel.

Don't let the bearings get too hot—oil them often enough to prevent this; for, as before mentioned, this sometimes bursts wheels.

When you order wheels, tell the maker just what work you want them for. If there is any reason why you cannot run them at the recommended speed, better mention that too. If you have a piece of a wheel which has given good results, it isn't a bad plan to send it to the maker; then he can send you another wheel just like it.

The speed of wheels is important, and affects their work very materially. About 5000 ft. a minute is recommended, as before stated, and this should be maintained as the wheel wears down. This requires a variable-speed countershaft, or, if a number of grinders are used, they can be run at different speeds, and the faster ones use wheels worn down by the first machines. The table shows the revolutions required to give the different surface speeds noted. If a wheel does not work just as you wish, try changing its speed; if this doesn't help it, notify the makers. Should it glaze or fill, it may indicate either that it is too hard or that it is running too fast.

Keep wheels true, both for better work and longer life of wheels. A little truing each day or so will save taking off a much larger amount a little later.

The table below designates number of revolutions per minute for specified diameters of wheels, to cause them to run at the respective periphery rates of 4000, 5000, and 6000 ft. per minute.

The medium of 5000 ft. is usually employed in ordinary work; but in special cases it is sometimes desirable to run them at a lower or higher rate, according to requirements.

The stress on the wheel at 4000 ft. periphery speed per minute is 48 lb. per square inch; at 5000 ft., 75 lb.; at 6000 ft., 108 lb. ('Railway and Locomotive Engineering.')

Table of Emery-Wheel Speeds.

Diameter of Wheel in Inches.	Revolutions per Minute for Surface Speed.		
	Of 4000 ft.	Of 5000 ft.	Of 6000 ft.
1	15,279	19,099	22,918
2	7,639	9,549	11,459
3	5,093	6,366	7,639
4	3,820	4,775	5,730
5	3,056	3,820	4,584
6	2,546	3,183	3,820
7	2,183	2,728	3,274
8	1,910	2,387	2,865
10	1,528	1,910	2,292
12	1,273	1,592	1,910
14	1,091	1,364	1,637
16	955	1,194	1,432
18	849	1,061	1,274
20	764	955	1,146
22	694	868	1,042
24	637	796	955
26	586	733	879
28	546	683	819
30	509	637	764
32	477	596	716
34	449	561	674
36	424	531	637
38	402	503	603
40	382	478	573
42	364	455	546
44	347	434	521
46	332	415	498
48	318	397	477
50	306	383	459
52	294	369	441
54	283	354	425
56	273	341	410
58	264	330	396
60	255	319	383

(*d*) *A useful emery wheel for small purposes.*—The illustration here given shows a simple plan of fitting up an emery wheel to be driven by foot-power. An old bicycle has its frame cut, as Fig. 168, and attached to a

wood framing. The base plank is 4½ ft. long, 1 ft. 4 in. wide, and 2 in. thick. The posts are 3 in. square, of hard wood. The ordinary concave rim of the wheel carries the band quite well and, fitted as shown, it is possible

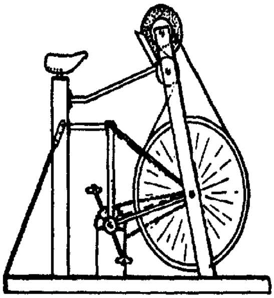


FIG. 163.

to get 1600 to 2000 revolutions per minute with ordinary pedalling. It will be noticed that it is the rear wheel of the bicycle that is used. The emery wheel is fitted by a mandril, so that wheels from 4 in. to 8 in. can be carried.

Buffing Wheels.—To obtain a smooth glossy finish to metals, the buff or polishing wheel is used, this imparting a brilliance much like that produced by the burnisher, but in much less time, and with far less labour. These wheels will take off a fair quantity of material when necessary, but are not equal to the emery wheel in this respect. When necessary the bulk of the material should be removed with these, and the polishing only done with the buff wheel. Polishing wheels were used for both purposes years ago before the solid wheels finally displaced them.

The emery wheel is made up solidly of emery with a binding material, as little as possible of the latter being used. The polishing wheel is made up of wood, covered with leather, and having emery on the surface only. As they have to be run at a very high speed, equal to, or higher than, that of the solid wheels, great caution has to be observed in so constructing them that they shall not fly apart during the running. The centrifugal force is so high in wheels run at high speed, that it is not rare for solid stone wheels to "burst" as it is called, and emery and other wheels are liable to this.

The best plan of construction is to build up the wheel in sections, each section "breaking-joint," and the wood considered best is yellow pine. Each layer of sections should be moderately thin, about ½ in. stuff, and the sections should be reasonably small. For small wheels, six sections are usual, while larger wheels—over a foot in diameter—may have eight. By this plan the effects of heat, moisture, or dryness of the atmosphere, will not be injurious, neither causing the wheel to warp, distort, nor otherwise alter its form. It will also be found that this mode of construction tends to increase the strength of the wheel above that of a wheel made in a solid piece.

In arranging the cut pieces for the sections, it is best to have the end grain towards the run of the wheel, as Fig. 164, this plan ensuring a more

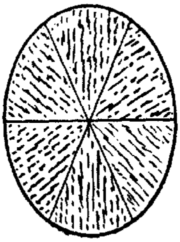


FIG. 164.

lasting wheel, one less likely to have pieces fly off it. With the grain as Fig. 165 it may be more convenient for gluing the leather upon the periphery, because glue holds much better

to the plank way of the grain than it does to end grain, as in Fig. 164. But the reason why that arrangement is more suitable than Fig. 165 is because there is little risk of pieces of the sections becoming detached and flying off. It is easy to see in Fig. 165

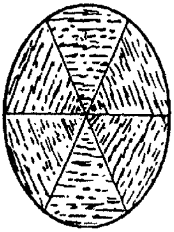


FIG. 165.

that there is a risk of pieces parting from the sections near the outer edges, and flying off by centrifugal force. With regard to the lack of holding power of the glue on the end grain in Fig. 164, the difficulty is got over by thoroughly filling up the end grain with plenty of glue before wrapping the leather round, and by taking especial care in the insertion of the pegs, in regard to number and position and their holding power.

When making up the wheel, first prepare the wooden outside, or face-plate, and then arrange to glue the first set of segments, or sections, on to this. It is best to let strips of paper come just where the joints in the sections come, as Fig. 166, so that there is a strip of paper between the set of sections, and the face-plate. The illustration shows the face-plate with four sections glued on. In making the glue do not let it be too watery; it should be as thick as can be conveniently used. Much depends upon its holding power, and thin, watery glue, which would be suitable for pattern work, would dry and crack, and fail to hold in an emery wheel. The glue should be newly made for this purpose.

When the glue of the first set of sections has become dry, a second layer or course is put on. It is important that the joints of this layer do not come directly over the joints of the first course, the joints must be "broken" as it is termed. The next

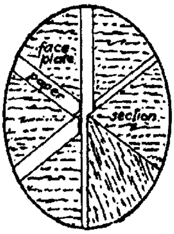


FIG. 166.

important step is the pegging. This is done with this second and the succeeding layers of sections. After the sections are glued on, a number of holes about $1\frac{1}{2}$ in. apart are bored with a $\frac{1}{4}$-in. bradawl, and pegs of pine are driven into these. The pegs can be cut to about $\frac{1}{16}$ in. square, and the ends dipped in hot glue just before being driven in. Having finished the second layer of sections, and allowed the glue to dry, the third and succeeding sections are put on in the same way.

The next step is to bore the wheel to take the spindle, and when this is fitted it can be turned on its own spindle. When the wheel is turned true the leather is glued on. This is first soaked in water to render it pliable, and the meeting ends are fitted with a long scarfed joint of from 3 in.

FIG. 167.

to 4 in. in length. If the wheel revolves in the direction indicated by the arrow in Fig. 167, the arrangement of the scarf is that shown. The hair side of the leather is laid next the wood,

the grain of the wood is well saturated and filled up with glue, and the leather strained round taut and pegged well. The work must be done in detail—that is, only as much of the leather must be glued at a time as can be pegged at once. It will be found that 4 in. to 5 in. is enough to deal with at once.

To give the leather a coat of emery, first glue the leather, and then roll it in emery. If the weather is cold the emery might be warmed, otherwise the glue will harden before the emery has well worked into it. When the glue and emery surface has become hard, the wheel may be put to use.

When the time arrives for the wheel leather to be re-coated with emery, by its having become worn smooth and irregular, the old emery must be removed before the new coat is put on. Warm water will soften the old coat so that it can be scraped off. The warm water should not be poured on, but be applied by laying fairly wet cloths or cotton waste around the wheel. The new emery surface is then applied as explained with a new wheel.

Glaze Wheels for Finishing Steel.—For hollow finishing the following wheels are prepared. A mahogany wheel for rough glazing. A mahogany wheel for smooth glazing. A lead wheel, or lap. For flat finishing: A buff wheel for rough. A buff wheel for smooth. A buff wheel for finishing. Lastly, a polisher. To make the glaze wheels: Get the spindles, and point them on each end; then get a block of beech and wedge it on the steel at one end with iron wedges, and turn it for the pulley for the band to run on. Take two pieces of flat mahogany, and glue and screw them together, so that the grain of one piece crosses the other, to prevent warping. Let it get thoroughly dry, and wedge it on the spindle, and turn it true. The lead wheel is made the same way, but made wider, and a groove is turned in the edge. Then the wheel is put into sand, and a ring of lead is run round the edge; it is then turned true. To make the buff wheels, proceed as with the glaze; but to save the expense, pine or deal wood will do as well as mahogany, only leave it about double the width of the glaze, which is about ½ in. wide, by 12–14 in. across. The buff wheels are covered with glue, and then the leather is tacked on with tacks driven in about half-way, so that they may be easily drawn out again. The leather is then turned true. The polisher is made the same way, but the size of the polisher must be a little less than any of the other wheels, say, about 1 in. The buff wheels are dressed by laying on a fine thin coat of clear glue, and rolling them round—No. 1, in superfine corn emery; No. 2, in smooth emery; No. 3, by making a cake of equal parts of mutton suet, beeswax, and washed emery; then it is held on the wheel while it is going round. The glaze wheels are dressed while using, by mixing a little of the emery with oil, and putting it on the wheel with a stick or the finger. The leather of the polisher is not covered with glue, but dressed with a mixture of crocus and water, not oil. Care must be taken to keep each wheel and substance to themselves, and the work must be carefully wiped after each operation; cleanliness must be studied above all things in using the polisher, as the slightest grease getting on it stops the polishing.

POTTERY.

(*See also* ENAMELLING, GLASS, TILES AND BRICKS, ETC.)

THE characteristic qualities common to all varieties of clay, and which determine even the making of the simplest pot, are two only. First the property of being kneadable when moist into almost any required shape (what we term plasticity), and, secondly, the property of becoming dense, hard, and durable when fired. These two qualities are possessed by different clays in very varying degree, and from these variations have sprung the broad distinctions between the different forms of pottery, so that when we speak of earthenware, stoneware, or porcelain, we are merely distinguishing between different varieties of pottery which have resulted from an extension by artificial means of variations already presented by certain natural clays. Thus, certain natural clays when fired produce a pottery which is porous and of no great hardness, while other clays fired at the same temperature would produce a form of pottery harder than the foregoing, and practically impervious to water. This is the broad general distinction between earthenware and stoneware, and the practical potter has simply succeeded in widening the difference between these natural products until he reaches forms as completely removed from each other as a porcelain cup and a salt-glazed drain-pipe.

Bodies.—English porcelain and earthenware are made from the following bodies, which are prepared by soaking the clays in a large vessel of water, and, when of the consistence of slip, passing them through the finest silk lawn into another vessel in which proper gauges are fixed, so that the other materials may be afterwards added in a slip state. Clay slip should weigh 12¼ lb.; Cornish clay, 13¼ lb.; Cornish stone, 16¼ lb.; and flint, 16¼ lb. a gallon. The passing through the lawn is repeated as often as is needful, so that the mixture may be deprived of impurities. Care must be taken that the bones used for china bodies are not decayed, and for the other materials used in making porcelain, great care is necessary to see that they are of the purest kinds. These bodies fire at a higher temperature than that usually observed, and are placed and fixed in the furnace with ground flint. For the coloured bodies the marls used should be selected of the finest quality, argillaceous marl being the best; and very fine lawn will be required if it is intended that the body should be clean and free from metallic spots. Clays in which the silicious ingredients are in proportion of three to one are the best for the use of porcelain; those in which argil is in excess are the best for coarser earthenware, because less acted upon by alkalies. The colours in clays produced by vegetables or bituminous particles are destroyed by heat in an open fire, and are by no means prejudicial; but those which arise from metallic particles are obstinate, and should be avoided as much as possible. Clays which contain argil and silex only are very refractory, but calcareous earths in the proportion of 10 to 12 per cent. will render any clay fusible. The clays for porcelain should be those which contain the most sand, and are of the greatest fineness; also such as do not retain water with too much tenacity, which is the case when argil is not combined with fixed air, therefore all clays ought to be exposed to the action of the atmosphere for a long time previous to using. Calcareous earth in its common form is limestone or spar, magnesia, etc., which in their pure state are not so easily dissolved as when combined with fixed air. Argillaceous clay or alumina clay forms the basis of common alum; is called argil, and is never found pure; the finest part is extracted from alum, and is not fusible in the strongest heat required for china or earthenware.

Argil in its usual state of dryness is capable of absorbing 2½ times its weight of water. Siliceous earths found in a stony state abound in flint; the purest are found in crystals and quartz of a pure white; fixed alkalies, vegetables, or minerals are their true solvents. It should be understood that flint and bones, in all instances, are to undergo the process of calcination previous to using.

Articles formed of one of the bodies are first moderately burned in earthen pots, to receive a certain degree of compactness, and to be ready for glazing. The glaze consists of an easily melted mixture of some species of earths, which, when fused together, produce a crystalline or vitreous mass; this, after cooling, is very finely ground and suspended in a sufficient quantity of water. Into this fluid the rough ware is dipped, by which the glazing matter is deposited uniformly on every part of its surface. After drying, each article is thoroughly baked or fired in the violent heat of the porcelain furnace. It is usual to decorate porcelain by paintings, for which purpose enamels or pastes, coloured by metallic oxides, are used, so easy of fusion as to run in a heat less intense than that in which the glazing of the ware melts.

Black Egyptian.—235 parts blue clay, 225 calcined ochre, 45 manganese, 15 Cornish clay; the materials must be accurately examined on account of the manganese, which ought to be free from lime or other calcareous earth; the pieces of ware when manufactured are very apt to crack, because of the sudden transition from heat to cold, provided above a certain proportion of lime is contained in the manganese. This kind of earthenware requires only once burning, after which it is scoured with fine sand, and then a small quantity of oil is rubbed over it.

Brown.—50 parts red clay, 7½ common clay, 1 manganese, 1 flint.

Calcedony.—32 parts yellow clay, 10 Cornish clay, 4 flint.

Common Brown or Cottage.—20 parts red or brown clay, 8 Cornish clay, 4 blue clay, 2 flint.

Cream Colour.—(*a*) Superior.—1½ part blue clay, 1½ brown clay, 1 black clay, 1 Cornish clay, 1 flint, ½ Cornish stone.

(*b*) Common.—1½ part blue clay, 1½ brown clay, 1½ black clay, 1 flint.

Drab.—24 parts argillaceous marl, 48 Cornish stone, 24 blue clay, 10 bones, 1 calcined nickel.

Fawn, or Drab.—40 parts marl, 4 Cornish clay, 1 flint.

Fawn, Porous.—40 parts argillaceous clay, 4 blue clay, 2 flint. This body makes porous wine and butter coolers, and water bottles, on the principle of absorption and evaporation. The articles are generally ornamented with various coloured clays; they should be kept in the wet clay state, at the time of being painted, otherwise the different colours laid upon them will not sufficiently adhere, but are liable to chip and peel off when burned. A moderate degree of heat must be applied, as too great a temperature will cause the body to be too dense, and prevent absorption; it will therefore be necessary to fire such articles in the easy parts of an earthenware biscuit oven.

Ironstone.—(*a*) 300 parts Cornish stone, 250 Cornish clay, 200 blue or brown clay, 100 flint, 1 blue calx.

(*b*) 175 parts Cornish stone, 150 Cornish clay, 90 blue or brown clay, 35 flint, 5 body frit, ½ blue calx. These bodies are very ductile, and fire at the temperature of the common biscuit oven; each piece of ware should be perfectly dry when placed in the seggars, because they are made a great deal thicker than any other kind. Setters also should be used at the bottom of each piece, and ground flint applied, but not sand, for the placing or seating; the body, when burned, is quite vitrified, and the pieces of ware are strong and heavy, ringing remarkably shrill.

Jasper.—10 parts chalk, 10 blue clay, 5 bones, 2 flint, 1½ blue calx. All the materials should be ground

together, as much depends on the different articles being well united, which adds greatly to the fineness in colour and lustre. It fires at the temperature of earthenware ovens.

Lilac Porcelain.—200 parts bones, 115 Cornish clay, 25 blue clay, 20 flint, 15 chalk, 10 Cornish stone, 1½ blue calx.

Porcelain.—(*a*) 360 parts bones, 230 Cornish clay, 50 Cornish stone, 20 flint, 20 blue or brown clay, 10 body frit, ¼ blue calx.

(*b*) 400 parts bones, 360 Cornish clay, 250 Cornish stone, 20 flint, ¾ blue calx.

Printed Earthenware.—(*a*) Superior. 3 parts blue clay, 1 black or brown clay, 2 Cornish clay, 1½ flint, ¾ Cornish stone.

(*b*) Common.—2 parts blue clay, 2 brown or black clay, 1 Cornish clay, 1½ flint.

Ring.—150 parts blue clay, 100 Cornish stone, 100 bones, 52 plaster. Used for making rings and setters, for placing porcelain and ironstone; the porcelain clay which gets dirty or injured by working may be used for the same purpose, in the proportion of two of the former to one of the latter.

Saucer Mould.—10 parts flint, 4 blue clay, 2 Cornish clay, 1 black clay. Prepared for the sole purpose of making moulds, principally those of saucers; moulds made in this way are preferable, and considerably more durable than those which are made of plaster; the contraction of this clay in burning is inconsiderable.

Stone.—480 parts Cornish stone, 250 blue and brown clay, 240 Cornish clay, 10 glass, 1 blue calx. This body will be sufficiently vitrified at the temperature of the earthenware biscuit oven, and is adapted for the purpose of manufacturing jugs, mugs, and so on; it is requisite to place rings on each piece of ware, in order to keep them from being crooked when burnt in the oven; in all other respects to be treated as earthenware bodies.

Stone Mortar.—480 parts Cornish stone, 250 blue and brown clay, 240 Cornish clay, 10 glass, principally used for making stone mortars, and when burnt is of a yellowish white, absolutely vitrified, exceedingly strong, very durable, and produces a clear bell sound.

White.—50 parts chalk, 50 blue clay, 25 bones, 10 flint. This body is of the same consistence, and requires the same temperature as the jasper body. It is perfectly adapted also for the purpose of figures in bas-relief, and other ornamental work.

Coloured Clays.—These clays are for the purpose of painting porous coolers and bottles in the Mosaic style, and are equally applicable to the ornamenting of china and earthenware; the mixtures must be well ground, for their fineness has a great tendency to equalise the contraction and expansion of bodies in firing.

Black.—4 parts black Egyptian clay, 1 white clay, 1 blue clay.

Blue.—30 parts blue clay, 1 blue calx.

Green.—12 parts white clay, 1 nickel, ½ blue clay.

Orange.—4 parts yellow clay, 2 Cornish clay, 1 flint, ½ Cornish stone.

White.—4 parts blue clay, 2 Cornish clay, 2 flint, 1 Cornish stone.

Colours under Glaze, with the exception of the green, should be mixed together and calcined in a reverberatory furnace or glazing oven, in seggar hillers, or dishes lined with flint; then spread on the mixture about an inch in thickness, observing that the hiller or dish have a sufficient access of air allowed, to prevent the metals from reviving again in their metallic state; the green ingredients only require grinding.

Naples Yellow.—12 parts white-lead, 2 diaphoretic antimony, 1 crude sal ammoniac, ¼ alum. Mix intimately, calcine in a crucible, over a slow fire, for the space of three hours, stirring it nearly the whole of the time, when the mass will be found of a beautiful yellow or gold colour.

Lining Brown.—7 parts glass of

antimony, 3 raw litharge, 2½ manganese, 1 nitre, 1 blue calx.

Painting Brown.—5 parts glass of antimony, 5 raw litharge, 2 manganese, ½ blue calx.

Orange.—6 parts raw litharge, 4 crude antimony, 2 crocus-martis, 1 tin oxide.

Yellow.—4 parts raw litharge, 3 crude antimony, 1½ tin oxide.

Printed Brown.—5 parts raw litharge, 5 crude antimony, 2½ manganese, 1 blue calx.

Printed Black.—3 parts red-lead, 1½ antimony, ¾ manganese. After these ingredients have been calcined, add the following, and calcine again: 2 parts blue calx, ½ tin oxide. This black under glaze, in the last stage of preparation, must be calcined in the highest heat of a biscuit oven, and crystal glaze is the most suitable to it. The ware must be fired in an easy part of the glazing oven; the brown calcined in the usual way, and dipped in the common printed glaze.

Printed Mulberry.—4 parts manganese, 2 blue calx, 1 nitre, ½ borax, calcine this colour in the usual way, either in a dish or seggar hiller, and after the mixture is spread on the dish or hiller, a small quantity of pounded nitre should be scattered thinly over, and when calcined, add 2 parts flint glass, 1 flint; then grind all the ingredients up together for use.

Green for Edging.—3 parts copper oxide, 3 flint glass, 2 flint, 2 tin oxide, 1 enamel blue. Grind these ingredients together, after which add 8 qt. earthenware printed glaze, and 4 qt. cream-colour glaze, mix well together and sift them through a fine lawn. Lay this green on the ware after it is dipped, and fire it in the coolest part of the glazing oven.

Blue Printed Flux.—(*a*) 2 parts flint, 1 frit for glazes, ½ flint glass. (*b*) 5 parts flint, 1½ borax, ½ nitre. (*c*) 3 parts flint glass, 2½ flint, 1 nitre, 1 borax.

Printing and Edging Blue.—2 parts blue calx, 3 frit for glazes, 1½ flint glass, 1 flint, ½ white-lead. The frit should be prepared without the tin oxide, when mixed with the blue calx, for that metal and arsenic are both prejudicial to its colour.

Strong Printing Blue.—2 parts blue calx, 3 blue printed flux.

Weak Printing Blue.—1 part blue calx, 4 blue printed flux (*b*).

Enamels and Fluxes.—The enamels, after being finely ground, should be thoroughly dried; then mixed up with turpentine, and used like other colours with a pencil; after which fused again, and vitrified by fire. Spirits of tar may be substituted instead of turpentine in all enamels, with the exception of blue and colours prepared from chrome. With regard to the burning, the lustres will bear the highest temperature of an enamelling heat: the rose colour, cornelian red, and pomona green require a less degree of heat, and are generally placed in the middle of the kiln or muffle, as well as burnish gold; other colours are not so susceptible of being destroyed by heat, and will fire in any part of the kiln or muffle. The even surface of the various coloured grounds on china is produced by first laying the space wanted with linseed-oil, previously boiled with a little red-lead and a small portion of turpentine; the enamel colour is then ground fine, and dusted on the oiled part with cotton wool or laid on with a large camel-hair pencil. The component parts of the different colours are as accurately stated as possible, but the preparation principally depends on observation, therefore experiments will be necessary that a proper judgment may be formed.

Balsam of Sulphur.—Take 2 parts flower of sulphur, and 4 of turpentine; put them in a vessel over a slow fire until the sulphur is completely dissolved; after which add 8 parts linseed-oil, and continue the same degree of heat for about one hour; previous to becoming cold, strain it through a piece of cloth.

Black Enamels.—Copper black is a

very fine colour, the obtaining of which depends upon a proper temperature of heat being applied, for nothing is more fickle and uncertain; if in the least degree overfired, the colour is destroyed, and becomes of a dirty green. The other blacks are called umber blacks, and will stand any degree of heat which is required in an enamelling kiln or muffle. The umber to be highly calcined in a biscuit oven, but particular caution should be observed that it is the real Turkey umber, and not the English, which is of an inferior quality. The two first enamel blacks to be calcined in the usual way; the materials of the two latter only want grinding.

Enamel Painting Black.—4 parts borax, 2 calcined umber, 2½ red-lead, 2 enamel blue, 1 flint, 1 blue calx. A superior black enamel is composed by uniting with 8 parts of this composition, 1 enamel, 1 enamel purple.

Enamel Printing Black.—1 part calcined umber, 1½ calcined borax, ½ blue calx.

Copper Black Enamel.—1 part copper calcined, 3 enamel flux (*a*).

BLUE ENAMELS.—For these the materials must be calcined in an air furnace or glazing oven, and caution should be observed that they are not too finely ground at the mill, in order to prevent them from crazing or chipping after being burnt on the pieces of ware. (*a*) 16 parts flint glass, 5 red-lead, 2 white enamel, 2 blue calx, 1 common salt, 1 potash. (*b*) 16 parts flint glass, 5 red-lead, 2 nitre, 2 potash, 2½ blue calx.

Blue Calx.—(*a*) 30 parts refined regulus of zaffre, 1 plaster, ½ borax. (*b*) 30 parts refined regulus of cobalt, 1 plaster, ½ borax. These materials to be made very fine, and well mixed; put the mixture in earthenware biscuit cups 1½ in. high, 3 in. diameter, and 1½ in. thick, filled nearly to the top; set them in a furnace, the fire to be increased until the mixture is in a state of fusion; the same degree of heat must be continued for about six hours afterwards, and then the fire hastily slackened; this operation will occupy 12-13 hours; at the top of the cups will be found a blue calx separated from the nickel; but as a large proportion of blue will still remain in the nickel when sunk to the bottom of the cups, it will be necessary, in order to procure the whole of the blue contained, to pursue precisely the same method over again.

Cobalt Blue or Regulus of Cobalt.—60 parts cobalt ore, 50 potash, 25 sand, 10 charcoal. Work the same way as for regulus of zaffre.

To Refine Regulus of Cobalt.—50 parts regulus of cobalt, 6 potash. Refine as for regulus of zaffre; the operation of refining must be repeated until the scoria is of a bright colour and of a slight bluish hue; then spread the purified metal, finely pulverised, ½ in. thick, on flat pieces of earthenware covered with flint; place in a reverberatory furnace, and apply a moderate degree of heat for a few hours.

Smalts.—32 parts sand, 32 potash, 10 borax, 1 blue calx. These smalts, the materials of which are calcined in the usual manner when finely pulverised will produce a fine rich-looking blue powder.

Regulus of Zaffre.—112 parts zaffre, 57 potash, 18½ charcoal. The charcoal being pulverised, and all the materials mixed up together, they are put into large-sized crucibles capable of holding 3-4 qt., and filled quite full, then placed in a strong brick-built reverberatory furnace, commencing with a slow fire, and continued for some time, but as soon as it is heated to a red-heat, it will require a considerably stronger fire before the cohesion between the different particles is sufficiently destroyed. This operation will be complete in about ten hours, the weight of the regulus being 31-33 lb.; on examining the scoria, if there remains mixed with it small pieces of metal like small shot, or when pounded, if the scoria has a bluish cast, the fire has not been strong enough; there is but little danger to be apprehended from the

most intense heat, provided the particles in fusion do not perforate the crucibles. At the bottom of each cake of regulus there will be bismuth slightly adhering, which is easily separated without the application of any great degree of heat, by placing the cakes upon an iron plate or pan, which will soon bring the bismuth into a state of liquefaction, and it can then be separated from the regulus.

To Refine Regulus of Zaffre.—50 parts regulus of zaffre, 6 potash, 3 sand, pulverise and well mix, then put in crucibles holding about 1½ lb. each, and fire in a reverberatory furnace, commencing with a slow fire, and gradually increase the heat for about eight hours; by that time the regulus will have fallen to the bottom of the crucible, and the scoria found at the top will be of a blackish green, it will then be that another course of refining should take place, in order that the regulus may be obtained in a more perfect state of purity.

BROWN ENAMELS. *Dark.*—1 part copperas calcined brown, 2 enamel flux (*d*), ¾ enamel flux (*a*). Brown enamel only requires grinding before it is fit for use; the copperas for the purpose of making dark brown will require calcining in the most intense heat of a biscuit oven; the colour of it varies according to the temperature it undergoes, first white, then orange, red, and lastly brown.

Light.—1 part calcined umber, 1 yellow under glaze, ½ copperas calcined red, ½ white enamel, 4½ enamel flux (*b*), 3 enamel flux (*c*).

ENAMEL FLUX.—(*a*) 8 parts red-lead, 6 flint glass, 3 borax, 3 flint. (*b*) 7 parts red-lead, 4 borax, 2½ flint. (*c*) 4 parts borax, 3 red-lead, 3 flint glass, 2 flint. (*d*) 8 parts red-lead, 1 flint glass, 1 flint.

GOLD FLUX.—11 parts borax, 5½ litharge, 1 silver oxide. In these enamel fluxes the materials are to be made very fine, particularly the flint, and mixed well together, so that the particles may more easily concrete when in a state of fusion; then calcined in an air furnace or an earthenware glazing oven, when the whole mass, by means of the proper temperature of fire, will be changed into a brittle resplendent and transparent glass.

Gold Bronze.—2½ parts burnish gold, 2 copper oxide, 1 quicksilver, ½ gold flux. Having dissolved the copper in aqua fortis, it is again separated from its solvent, and falls to the bottom of the vessel by the addition of iron; the precipitate of copper may be increased or diminished at discretion, which makes the bronze richer or poorer in colour according to the proportion of burnish gold contained in the mixture. It is chiefly used for ornamenting the handles and heads of jars, vases, and so on, and occasionally intermixed with burnish gold.

Gold Solution.—Put 40 dwt. aqua regia in a small bottle, to which add 5 dwt. grain gold; the solution will immediately commence, and may be observed by the effervescence which arises at the time; when the solution is complete, the whole of the gold will be dissolved, which will be accomplished in about two hours if the acids be genuine, but when they are not, it will be requisite to apply heat to facilitate the solution.

Burnish Gold from Brown Gold.—12 parts brown oxide of gold, 8 quicksilver, 2 silver oxide, 1 white-lead. Put the whole of these ingredients into an earthenware mortar, and triturate them until the whole is amalgamated; the mercury being the solvent fluid, very readily combines with the rest, to which it communicates more or less of its fusibility, after which grind them very fine with spirits of turpentine.

Burnish Gold from Green Gold.—12 parts green gold, 7½ quicksilver, 1½ silver oxide, 1½ gold flux. Place the gold in an earthenware vessel on an open fire, and when heated red hot, take four times its weight of mercury, and pour it in; the mixture to be stirred with a little iron rod; the gold will be dissolved; it is then thrown into a vessel full of water until it co-

agulates and becomes manageable; much of the mercury is then pressed through a piece of leather, and the rest is dissolved by a quantity of nitrous acid; the acid is afterwards poured off, the gold remaining is repeatedly washed with boiling water as often as needful; it is then dried and mixed up with the other ingredients, and ground with spirits of turpentine for use.

Gold Lustre.—Take grain gold and dissolve it in aqua regia, as for solution of gold; add 5 gr. tin; an effervescence takes place when the solution is completed and in a proper condition to be mixed; take balsam of sulphur 3 parts, spirits of turpentine 2 parts, mix them well together over a slow fire, then gradually drop the solution of gold into the menstruum, and keep stirring until the whole solution be added; provided the mixture should appear too thick, add more turpentine till of a proper consistence. 1 oz. gold dissolved in the manner described will make upwards of 2 lb. prepared lustre, and must be used with turpentine, for all other spirits are injurious.

Persian Gold Lustre.—Take any quantity of the precipitate of gold, first mixed with a small portion of fat oil on a flat piece of earthenware, then place it on a stone previously heated, and when the mixture begins to be in an eliquated state, stir it well with a palette knife, and keep adding more oil by a little at a time, until with the continuance of a gentle heat it assumes the colour of balsam of sulphur, then add, with a less degree of heat, turpentine in small quantities. 1 oz. of the precipitate of gold will make about 1 lb., more or less, of lustre, having more solidity and opacity than gold lustre. The proportions of the fat oil of turpentine to the spirits of turpentine, are 1 part of the former to 3 of the latter.

GREEN ENAMELS. *Blue Green.*—42 parts red-lead, 15 flint, 12 borax, 2¾ blue vitriol calcined. To these materials, after being calcined in an air furnace or glazing oven, must be added 12 parts white enamel, then grind them all together.

Grass Green.—3⅜ parts blue green frit, 1 enamel yellow.

Yellow Green.—2½ parts blue green, 1 enamel yellow.

Pomona Green.—1 part oxide of green chrome, 2½ enamel flux (*a*), 1½ enamel flux (*d*). This green is prepared by simply grinding the ingredients, and produces that dark colour equal to the French green, provided the oxide is genuine; and by adding a proportion more of flux and white enamel, there still will be a rich tint, though weaker and lighter in colour.

ORANGE ENAMEL.—1 part orange under glaze, 2 enamel flux (*a*), 1 enamel flux (*d*).

PLATINUM LUSTRE.—Dissolve platina as for silver lustre. Let the solution fall into a large vessel of water at the temperature of blood-heat; the sal ammoniac must then be added, and the precipitate will immediately descend to the bottom of the vessel in an orange-colour powder; decant off the water, and repeatedly apply to the precipitate boiling water until the water becomes quite insipid; after being gradually dried it is then used for the purpose of producing a silver lustre in the following manner: First, procure brown earthenware of a full soft glaze, and with a broad camel-hair pencil lay on all over the piece of ware the platina in solution, and fire it at a strong enamelling heat, by which it will acquire a shining steel-colour lustre; then take the platina oxide mixed up with water to a thickish consistence, and lay it on the steel lustre, and fire it again in a kiln or muffle, but not to exceed a blood-red heat; it is then called silver lustre, being less resplendent, having more solidity and whiteness, and a very similar appearance to silver. On all white earthenware the platina in solution is perfectly sufficient to produce a silver lustre.

PURPLE ENAMEL.—4 parts gold in solution, 1 tin in solution. Procure a vessel to contain 50 parts of water

about the temperature of blood-heat, to be well mixed with the solution of gold, and then add the solution of tin by dropping it into the menstruum, at the same time constantly stirring it with a strong feather, which will produce a fine purple-colour liquor; but it will be necessary to add a few drops of the solution of silver, which will much assist to raise the colour and beauty of the purple; to help the precipitation of the gold from its solvent (provided the precipitation does not immediately take place) add a large proportion of boiling water or a small quantity of sal ammoniac, and a precipitate will instantly be procured; the clear liquor must then be decanted off, and the boiling water repeated until it is completely insipid. The residue consists of the oxides of gold, tin, and silver in combination, and is the only substance which has the property of communicating the purple colour to enamel glass; after the precipitate is prepared, the flux must be added; the proper quantity will solely depend on the fusibility or softness of the flux, and as the operation in a great measure depends on observation, a few experiments by the operator will be found useful. To the purple precipitate may be added 30–45 enamel flux (*c*), according to the strength of colour intended to be made.

Purple Distance.—2 parts enamel purple, 3 manganese oxide, 12 enamel flux (*c*).

RED ENAMELS.—1 part green copperas calcined, 3 enamel flux (*c*). The greatest difficulty in preparing red is the calcination of the copperas; calcine the copperas in a vessel exposed to the heat of an open fire, by which means it will dissipate all its volatile contents, and leave a residue of iron oxide in powder; when it attains an orange or light red, the calcination is sufficiently accomplished; the residue is then washed repeatedly with boiling water, until the water becomes insipid and free from sulphuric acid.

Cornelian Red.—1 part iron chromate, 2¼ enamel flux (*d*). This fine colour is produced from iron chromate, which has a greater affinity for lead than an alkali, consequently the flux prescribed is the only one which is susceptible of yielding its proper colour, as those fluxes which contain a large proportion of borax are very prejudicial, destroying the colour, and with the greatest difficulty forming any affinity at all, therefore should be avoided. The flux used should be highly calcined until it assumes a dark orange-coloured glass. Mix up with spirits of turpentine when dry.

Rose Colour.—3 dwt. gold in solution, 60 leaves book silver, 2¼ lb. enamel flux (*a*). Procure a vessel to contain 10 parts the quantity of hot water, then mix the water and gold together while the water is at the temperature of 190° F.; add pulverised sal ammoniac rather copiously, at the same time briskly stirring the mixture with a strong feather, until the appearance of a decomposition takes place, which will soon be observable by the gold being precipitated from the menstruum in the form of a fine yellow powder; when that is accomplished, let the vessel stand undisturbed a short time to allow the precipitate to subside, then decant the liquor off, and still add boiling water repeatedly to the precipitate until the water is perfectly insipid; in the next place put it on a plaster bat to dry, after which it must be mixed up with book silver and flux, according to the proportions given above, and well triturated in a mortar; then send it to the mill to be ground, when it will be in a proper state for use. This colour is supposed to be best when of a purple tinge, which may be produced by merely calcining the preparation to the heat of ignition previous to being ground; if the colour be too dark, the mixture does not possess a sufficient quantity of silver; if it is too light, the silver must have been very plentifully added, therefore the operator must add or diminish accordingly. Great caution must be observed with this receipt, as the gold precipitated by the sal ammoniac will

unite with it, and then has the property of fulminating; and when gently heated or smartly struck with any hard instrument will immediately detonate; this can only be obviated by a plentiful use of boiling water; a caution which ought to be strictly attended to, as it removes the dangerous quality by depriving the gold of its salt.

SILVER OR STEEL LUSTRE.—This is prepared by taking platina and dissolving it in aqua regia composed of equal parts of spirits of nitre and muriatic acid. The solution must be placed in a sand bath at a moderate temperature; then take 3 parts of the spirits of tar, and 1 part of the solution of platina, mixing the solution with the tar very gradually, for as soon as the combination takes place, an effervescence will arise, the nitrous acid will evaporate and leave the platina in combination with the tar. After the above process has been performed, should the menstruum be found too thin and incapable of using, set it on a sand bath as before for a few hours; the spirit of tar will evaporate, and by that means a proper consistence will be obtained. It must be used with spirits of tar.

Silver Solution.—1 part nitric acid, and 3 of boiling water; add one-third of its weight of silver, dilute with 5 times its quantity of water, then add a portion of common salt, stirring it all the time; immediately a white precipitate will fall to the bottom of the vessel; the liquor must then be decanted off and boiling water repeatedly added, until the water is quite insipid. This precipitate is the pure oxide of silver, and is the same as that used in the preparation of burnished gold.

TIN SOLUTION.—2 parts nitrous acid, and 1 part muriatic acid, with an equal part of water; add granulated tin by small pieces at a time, so that one piece be dissolved before the next is added. This aqua regia will dissolve half its weight of tin; the solution when properly obtained is of a reddish brown or amber colour, but when gelatinous the solution is defective.

Tin Oxide.—Take any given quantity of grain tin, and melt in an iron ladle; when in fusion, pour it into a vessel full of cold water, by which means the tin will be reduced into small grains or particles adhering to each other; then take a biscuit dish previously lined with flint, spread it slightly over with pounded nitre, take the granulated tin and lay it on the dish 2 in. thick, adding a little more nitre on the top; 1 lb. nitre will be sufficient to oxidise 5 lb. granulated tin; the dish containing the tin and nitre is to be calcined in a reverberatory furnace or glazing oven; particular attention is required in heating it, so that plenty of room remains to admit a free access of air to pass over the metal, otherwise it is impossible to obtain the whole of it in an oxidised state.

WHITE ENAMELS.—These require the materials to be made very fine and calcined in air furnace, the heat at first to be generated very gradually; and when the whole mass is in a state of fusion, increase the fire quickly, and there will soon be produced a fine white enamel; in the time of fusion it will be requisite to keep stirring the whole together with an iron spatula or rod.

Venetian White.—3½ parts flint, 3 calcined borax, 1 Cornish stone, ½ tin oxide.

Common White.—8 parts flint glass, 2 red-lead, ½ nitre, ½ arsenic.

YELLOW ENAMEL.—1 part Naples yellow, 2 enamel flux (*a*), 1 enamel flux (*c*).

Glazes.—There are 3 sorts of glazes—viz. lead, salt, and felspar. *Lead glaze* can be formed in two ways. (1) The biscuitware is dipped into a tub containing a mixture of about 60 pints litharge, 10 clay, and 20 ground flint, diffused in water to a creamy consistence. When taken out, enough adheres to give a uniform glazing when re-heated. The pieces are then again packed up in baked

clay cases resembling bandboxes, called seggars, with small bits of pottery between, and fired in a kiln. The glazing mixture fuses at a very moderate heat, and gives a uniform glossy coating. (2) The common clay vessels are painted over with red-lead. If the vessel thus painted is exposed to a moderate red heat, a glaze is produced. These red-glazed vessels are most dangerous for household use, since the glaze is dissolved off by acid. *Salt glaze* consists in throwing common salt into the kiln in which the vessels are heated. The salt is volatilised and decomposed by the joint agency of the silica of the ware and of the vapour of water always present. Hydrochloric acid and soda are produced, the latter forming a silicate, which fuses over the surface of the ware, and gives a thin but excellent glaze. *Felspar glaze* may be either ground felspar or a mixture of gypsum, silica, and a little porcelain clay diffused through water. The piece is dipped for a moment into this mixture, and then withdrawn; the water sinks into its substance, and the powder remains evenly spread upon its surface; it is once more dried, and lastly, fixed at an exceedingly high temperature. The coarse stone-ware made at Bristol is glazed by the vapour of common salt, as is also the Staffordshire flint-ware. The latter is the better. The yellow glaze is made by mixing together in water, till it becomes thick like cream, 112 lb. white-lead, 24 lb. ground flint, and 6 lb. ground flint glass. Manufacturers in this differ. Nottingham black glaze: 21 parts white-lead (by weight), 5 powdered flint, and 3 manganese. Another method is to immerse dried pottery in sea-salt, and bake.

Earthenware.—(1) For the glaze, a mixture of borax, Cornish stone, calcic carbonate, flint, and kaolin, is first fused in a small reverberatory furnace, shown in section in Fig. 168: A is the stokehole; M, fire-place; N, grate; K, damper; HSB, bed on which the mixture rests, having been thrown in at V; P, chimney; R, opening by which the mixture, when thoroughly fused, is run out into an iron vessel containing water. The molten mass is broken up by the cold water, and is transferred to small mills, similar

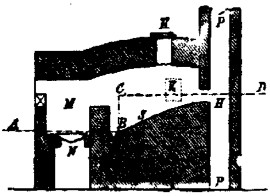


FIG. 168.

to those employed for grinding flint and Cornish stone. After prolonged grinding with water, and passing through sieves of great fineness, it is purified by agitation in a blunger armed with horse-shoe magnets. A proportion of this slip is mixed with a slip consisting of Cornish stone and plumbic carbonate, or an equivalent of plumbic oxide. Into this liquid mixture, contained in convenient tanks, the wares, rendered porous by burning, are dipped; the mixture is kept in constant agitation, and the porosity of the ware ensures enough being taken up to produce a sufficient glaze. Considerable skill is required to dip the different forms of ware in such a manner that the glaze may be equally distributed, and as little surface as possible be covered by the dipper's hand. When the parts that have been rubbed, or insufficiently covered with the liquid glaze, have been retouched, and the ware has been thoroughly dried, it is replaced in seggars, preparatory to the fusion of the glaze. The ware can no longer be packed one piece upon another, as in the previous firing, for the fusion of the glaze would cause the pieces to adhere, and great damage would ensue. The ware is therefore separated by the insertion of props of refractory

clay, made in such form that as small a part of the ware as possible shall be touched. The seggars with their contents are built up in a kiln similar to the one employed for the first firing, only somewhat smaller. The seggars, as in the previous case, are made air-tight by the insertion of rolls of plastic clay. The firing lasts some 18 hours, and its progress is tested by the removal of pieces of ware similar to that being fired, and previously dipped in the same glaze. The test-pieces are usually made on purpose, and pierced in the centre to facilitate removal. (Powell.)

(2) Silicate of potash or soda at 35° B. may be used either alone or mixed with 20 per cent. of red-lead and 5 per cent. of silica. The thick varnish is brushed over the half-burnt articles, which are then dried and burnt. The same glaze can be used for statuettes, etc., being quite indestructible when properly burnt in. ('Dingl. Pol. Jl.')

(3) (*a*) Silicate of soda at 50°B., 100 parts; powdered quartz, 15; chalk from Meudon, 15. (*b*) Silicate of soda at 50°B., 100 parts; powdered quartz, 15; chalk, 15; borax, 10. This is quite free from poisonous ingredients, and is used at the Lanilis pottery, near Brest. (Salvetat.)

(4) For clay tobacco pipes, requiring only moderate heat, so that in burning the pipes will not be baked too hard. (*a*) Make a saturated solution of sugar of lead (lead acetate) in hot water. Dip the pipes in this, or apply it with a brush to the outside, then dry and expose in an open muffle at a low red heat until properly glazed. (*b*) Potassium carbonate, 1 part; borax, 5; melt together in a sand crucible, pour out on an iron plate to cool, powder, and mix into a paste with a little turpentine oil for use. Apply with a brush or clean rag, and heat slowly in a muffle or oven to incipient redness.

(5) White earthenware glaze: 35 Cornish stone, 20 borax, 10 crystal soda, 20 red-lead, ½ blue calx; calcine, pulverise coarsely, and grind with 20 lb. white-lead, 10 lb. Cornish stone, and 5 lb. flint.

ALKALINE.—30 parts borax, 30 flint, 13 Cornish stone, 2 tin oxide. The materials must be calcined, and particular caution observed in the course of chipping from the seggars, that not the least particle of any colouring matter be mixed with it, for it is very susceptible of being materially injured in its colour; when ground, a small quantity of muriatic or nitrous acid should be added, and at the same time quickly stirred about, and the motion continued for some time, in order to prevent it setting at the bottom of the vessel; in all other respects treated the same as common glazes, except with regard to dipping, in which case it must be used very thin.

BLUE.—50 parts flint, 30 borax, 22 red-lead, 10 Cornish stone, 6 crystallised soda, 6 tin oxide, 3 blue calx. In preparing this glaze follow the same directions as for porcelain glaze.

Blue and Green Edge.—72 parts litharge, 36 Cornish stone, 20 flint glass, 17 flint, 12 frit for glazes (*b*), ½ blue calx. The blue and green edged ware when dipped in this glaze should be perfectly dry previous to being placed in the seggars, and the green edge should be seated in the coolest part of the glazing oven.

BROWN COTTAGE.—60 parts litharge, 32 flint, 8 brown slip. This glaze requires using about the same consistence as the cream colour glaze, and will stand the highest temperature of heat in a common glazing oven.

CALCEDONY.—65 parts litharge, 40 Cornish stone, 20 flint, 6 frit for glazes (*b*).

COMMON PRINTED.—90 parts white-lead, 45 Cornish stone, 22 flint, 20 flint glass, ½ blue calx. To this, after being properly ground and sifted, add 1 lb. common salt and ½ lb. borax, which forms a smear or flow, as it is generally termed, but must not be put into the glass until the blue stain is perfectly incorporated with it; the ware dipped therein must be placed in seggars washed with glaze.

CREAM-COLOUR.—(a) *Superior.*—85 parts white-lead, 40 Cornish stone, 22 flint, 16 flint glass, 8 frit for glazes (b).

(b) *Common.*—75 parts litharge, 40 Cornish stone, 23 flint, 10 flint glass.

CRYSTAL.—105 parts Cornish stone, 90 borax, 60 flint, 50 red-lead, 12 crystal soda, 10 tin oxide, ½ blue calx. This glaze produces very superior white earthenware, and, for the purpose of enamelling, the colours, lustres, and burnished gold appear to considerable advantage; it is also adapted for ironstone, and makes superior blue printed earthenware; it has a singularly striking effect on printed brown and mulberry. When used for dipping it must be considerably diluted, and requires but little shaking from the hand of the operator. It requires the heat of a china glazing oven, but to answer the earthenware oven a small addition of white-lead must be made, according to the temperature of firing. The materials must be mixed and calcined, and the ware fired in lime and slip seggars, well washed.

DRAB.—70 parts litharge, 30 flint, 25 Cornish stone, 10 drab slip.

EARTHENWARE PRINTED.—(a) *Superior.*—90 parts white-lead, 35 Cornish stone, 20 flint glass, 20 flint, 60 frit for glazes (b), 1 blue calx.

(b) *Common.*—85 parts white-lead, 35 Cornish stone, 22 flint, 15 flint glass, 24 frit for glazes (b), ½ blue calx. These glazes, when ground, to be sifted through a fine lawn; the former glaze is of the finest texture, and will require rather a thinner coating when dipped than those of common glazes. Fire in seggars, either washed with common glaze, or a mixture of lime and slip without flint.

FRIT BODY.—90 parts Cornish stone, 40 flint, 30 crystal soda, 8 tin oxide, 10 borax. This frit is used in small quantities, in china and ironstone bodies.

FRIT FOR GLAZES.—(a) 40 parts Cornish stone, 36 flint glass, 20 red-lead, 20 flint, 15 potash, 10 white-lead, 3 tin oxide. This frit is intended to be used in glazes, in lieu of those which contain a large proportion of borax; therefore substituting it when the price of that article is high, will, of course, be advantageous, and the texture of the glaze will still be good and admissible.

(b) 36 parts Cornish stone, 30 red-lead, 20 flint, 20 borax, 15 crystal soda, 5 tin oxide. These two frits may be calcined in the easy part of the glazing oven, in seggars lined with flint; particular care should be observed that they are clean chipped, and free from pieces of seggars, or any dirty substance.

GREEN.—3 parts blue vitriol, calcined, 1 flint glass, 1 flint. When ground, take 4 qt. of this mixture to 30 of the following mixture, ground: 35 parts litharge, 20 flint, 10 Cornish stone, 10 frit for glazes. This glaze is sufficiently fired in the coolest part of the glazing oven. Particular attention should be observed as to the proper wash used for the seggars, for much depends on that simple process. The brightness and lustre of the glaze will be secured by adopting the following wash: 5 parts solution of quicklime, 1 of clay slip, free from the least particle of flint, and applied about the thickness of common glaze.

IRONSTONE.—36 parts Cornish stone, 30 borax, 20 flint, 15 red-lead, 6 crystal soda, 5 tin oxide, ½ blue calx. With the above frit is to be added 15 parts white-lead, 10 Cornish stone, 10 flint; when ground together, the composition is ready for use; should the glaze prove too thin for dipping, add a small quantity of muriatic acid.

PORCELAIN.—(a) 40 parts Cornish stone, 45 red-lead, 38 borax, 32½ flint, 22½ flint glass, 13 crystal soda, 5 tin oxide, 1 enamel blue. The particles are made small and well mixed together, then calcined in coolest part of the glazing oven, in seggars thickly lined with flint; care must be observed that the frit is not too highly calcined, or brought into a high state of vitrification; if so, it will render it difficult to grind, and injure its good qualities in dipping. The frit likewise

if too finely ground will cause the glaze to be uneven on the surface of the ware; if any inconvenience of this nature arises, by adding a solution of potash in hot water, that defect will be instantly obviated.

(*b*) The material used for porcelain glaze is a natural mixture of felspar and quartz, and is known as "pegmatite." Its average composition is: silica, 74·3; alumina, 18·3; potassic oxide, 6·5; calcic oxide, 0·4; magnesic oxide, 0·2; water, 0·3; and it may be approximately represented by the formula $2(Al_2O_3, 3SiO_2) + K_2O, 3SiO_2$. It is therefore an ordinary glass, to which a second equivalent of aluminic silicate has been added, and the transparency of which is destroyed by the excess of infusible material. Each fresh supply of pegmatite is tested in order to ensure a constant result. For use, the pegmatite is first crushed under vertical grinding-wheels turning upon a revolving base. It is then ground with water in a mill with stone runners, and when reduced to a sufficient degree of fineness, is drawn off, sifted, agitated in the presence of magnets, in order to remove particles of iron, passed into a receptacle, and maintained in suspension by constant agitation. During the long process of grinding with water, great care must be taken to prevent a sudden precipitation of the material, either through the slackening or sudden stoppage of the stones. The tendency to precipitation may be retarded by mixing a small quantity of acetic acid with the water. Into the suspended pegmatite the biscuit ware is dipped, care being taken that no part of one piece remains in the glaze longer than another, and that the thick wares shall be dipped in a thin glaze, and the thin in a thick. The parts of ware which have been held in the dipper's hand are retouched with a brush dipped in the glaze. The wares are replaced in seggars, and the seggars are arranged in the lower division of the oven, the heat of which is more intense than in the biscuit-kiln. The entire absence of lead renders the glaze when fused exceedingly hard and durable; it is bluish in tint, and cold to handle. The grey tint of the body and glaze is due to the reducing action of the atmosphere of the kiln. The glaze is transparent and rather more fusible than the body, but becomes thoroughly incorporated with it, and, from its similarity of composition, expands and contracts uniformly with the paste. The bases of ware when removed from the seggars are rubbed smooth with sandstone. Owing to the difficulty of manipulating the paste, it is customary to build up elaborate vases from distinct pieces, which are joined together by metallic fittings; this especially applies to feet and handles. (Powell.)

(*c*) 40 parts Cornish stone, 45 red-lead, 38 borax, 32½ flint, 22½ flint glass, 18 crystal soda, 5 tin oxide, 1 enamel blue; make small, calcine, grind, and mix with water for dipping. (*d*) 40 Cornish stone, 36 flint glass, 20 red-lead, 20 flint, 15 potash, 10 white-lead, 3 tin oxide. (*e*) Crystal: 103 Cornish stone, 90 borax, 60 flint, 50 red-lead, 12 crystal soda, 10 tin oxide, ½ blue calx; this must be considerably diluted for dipping. (R. W. Hall.)

WHITE EARTHENWARE.—35 parts Cornish stone, 20 borax, 10 crystal soda, 20 red-lead, ½ blue calx. Calcine and then pulverise coarsely, and grind with 20 lb. white-lead, 10 lb. Cornish stone, and 5 lb. flint.

Printing Oil for Pottery.—(*a*) 1 qt. linseed-oil, ½ pint rape-oil, 2 oz. balsam capivi, 1 oz. pitch, ½ oz. amber oil, ½ oz. white-lead.

(*b*) 1 qt. linseed-oil, ½ pint rape-oil, ½ pint common tar, 1 oz. balsam sulphur, 1 oz. balsam capivi. The linseed-oil should be boiled for some time alone, then add the rape-oil and the balsam capivi, allow the boiling to be continued until it begins to approach the proper consistence, and add the remaining ingredients. The mixture should be allowed to cool a short time, after which the whole mass may be boiled slowly until it has assumed the

proper thickness; the vessel must be generally covered during the process, and the sulphur previously to being mixed with the oil should be perfectly pulverised, as by that means it is less liable to curdle the oil.

Stains for Pottery.—In preparing these stains the ingredients must be ground remarkably fine, and then so perfectly dried as not to leave the least humidity, after which they must be ground again with oil prepared for the purpose, composed of 2 parts balsam of sulphur, 1 part of amber oil, and as much turpentine as will render them of a proper consistence; they may then be used with ease for painting various devices on biscuit ware.

BLUE.—5 parts blue calx, 2 frit for glazes, without tin oxide, 1 flint glass. 1 enamel blue.

GREEN.—3 parts blue stain, 1 yellow stain, ½ enamel blue green.

YELLOW.—3 parts yellow under glaze, 1 frit for glazes, ½ chromate of iron.

Porcelain Colours.—The following are said to be some of the colour compounds used in the porcelain manufactory of Sèvres. Though intended for porcelain nearly all are applicable to glass painting if desired.

Fluxes. —No. 1, minium or red-lead, 3 parts; white washed sand, 1 part. Melt together and a greenish glass results. No. 2, take of No. 1 flux, 8 parts; fused borax in powder, 1 part; melt together and the result is a grey flux. No. 3 (used for carmines and greens); fused borax in powder, 5 parts; calcined flint, 3 parts; pure minium, 1 part. Melt together.

Colours.—*Indigo Blue.*—Oxide of cobalt, 1 part; No. 3 flux, 2 parts.

Deep Azure Blue.—Oxide of cobalt, 1 part; oxide of zinc, 2 parts; No. 3 flux, 5 parts.

Emerald Green.—Oxide of copper, 1 part; antimonic acid, 10 parts; No. 1 flux, 30 parts. Pulverise together and melt.

Grass Green.—Green oxide of chromium, 1 part; No. 3 flux, 3 parts. Triturate and melt.

Yellow.—Antimonic acid, 1 part; subsulphate of the peroxide of iron, 8 parts; oxide of zinc, 4 parts; No. 1 flux, 36 parts. Rub together and melt. If too deep a colour reduce the salt of iron.

Fixed Yellow for Touches.—The yellow just given, 1 part; white enamel of commerce, 2 parts. Melt, and pour out, and if not sufficiently fixed, add a little sand.

Deep Nankin Yellow.—Subsulphate of iron, 1 part; oxide of zinc, 2 parts; No. 2 flux, 8 parts. Triturate without melting.

Deep Red.—Take 1 part of subsulphate of iron, and calcine it in a muffle until it becomes a fine capucine red; No. 2 flux, 3 parts. Mix without melting.

Liver Brown.—Take 1 part of oxide of iron, made of red brown, and mix with it 3 parts of flux. If not deep enough add half a part of sienna earth.

White.—Use the white enamel of commerce.

Deep Black.—Oxide of cobalt, 2 parts; copper, 2 parts; oxide of manganese, 1 part; No. 1 flux, 6 parts; fused borax, ½ part. Melt, then add oxide of manganese, 1 part; oxide of copper, 2 parts. Triturate with melting.

Casting Process.—It is quite within the amateur's power to produce artistic pieces of pottery or porcelain if he has the interest to overcome preliminary difficulties, and if he has some artistic talent which is, of course, necessary for fine decorative pieces of work. It is not necessary that he should deal with the preparation of the raw clays as these can be purchased ready prepared for either earthenware or for porcelain. Assuming that the clays are prepared they (if necessary) are first screened. This is done by putting the material into a pail or tub of water, to slake, being left for two days to become thoroughly pasty. The mixture is then stirred with a wooden spatula and screened through

a brass gauge sieve No. 60. Any refuse that will not pass through the sieve is thrown away. The mixture is left to settle, which will take one or two days, then the water is poured off and the creamy paste poured into a pan made of plaster. This pan will absorb the remaining moisture, so that the paste soon becomes firm enough to work or "throw."

The next process is that of beating. It must be beaten and manipulated to render it homogeneous and particularly to expel all air bubbles. The latter cause blisters or small holes to appear during firing. Beating was originally done by working it with the naked feet, treading it, but in factories machinery is employed. The amateur, however, can do it with his hands. First prepare a firm table or bench, preferably with marble or slate top. Take sufficient paste to form a ball about 6 in. diameter, then with a wire cut this in half. A stiff upright wire can be arranged to extend from the bench to a bracket above, or a wire with handles, as used for cutting cheese, can be used. It should be of copper, and it may be here mentioned that iron is best not allowed to ever come in contact with the paste, particularly for porcelain. Cut the ball in two, then raise one half, dash it down on the other, then beat it a few blows with the clenched hand. Form it into a ball, cut it again and repeat the operation about twenty times. All this time the hands should be kept moist to prevent a dry crust forming by the heat of the hand, but the hands must not be so wet as to add moisture to the mass.

The next process is that of "throwing," this being the formation of the vase, or whatever piece of work is decided on, that can be made on the potters' wheel. This is the part that needs practice and perseverance, for there is no disguising the fact that "throwing" cannot be learned in a few trials. It may take a month or more, and is best practised with small pieces to begin with.*

The process is as follows: The operator first prepares a basin of slip (clear thin paste), and a little of this is thrown on the wheel-top. A plaster disc, ½ in. thick, is then put on exactly in the centre and this has some slip put on it sufficient to cover. This disc absorbs the moisture and quickly adheres to the wheel-top. As soon as the slip is put on the plaster disc, a ball of paste is put on and worked at once. The operator puts both hands on it (previously wetting his hands with slip and repeatedly doing so as required) and works it up and down by first pressing his hands outside so that the paste rises in a conical heap, then pressing his thumbs down in the middle that the mass forms a shallow thick basin. After doing this once or twice he commences to shape the mass to whatever form it is to take. One of the chief difficulties is to master the centreing of the piece, making the centre of the thrown mass exactly coincide with the centre of the revolving wheel, so that both work smoothly together. Practice is all that is required. Vases with good open necks are formed in one piece, but anything with a narrow neck is made in two pieces and joined with slip. This has to be done quickly and correctly.

When the piece is thus shaped, it must be left to get firm (but not at all dry), then it is subjected to a process called "turning." It is put back on the wheel for this (being again secured with slip), and while it is revolving, steel edged tools are held against it to remove superfluous matter and to sharpen up angles, grooves and recesses. Sometimes the tools are blades fastened on the ends of short metal rods secured in handles, but for small work they are simply sharp steel scrapers with one edge taking the outline of the form of the piece. Fig. 169 gives some examples. The surface, after being

* A short distance further on is described the practice of "castings," which is quite successful with porcelain and makes a knowledge of throwing quite unnecessary. It is a great encouragement to amateurs.

treated with these, can be polished by a scraper of thin iron, or by a moist sponge.

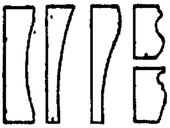


FIG. 169.

Pressing is a means of producing shaped vessels from the beaten clay without throwing or shaping on the potters' wheel. It is not so suited for small as for large and heavier pieces. Pressing is done with plaster moulds, the beaten clay being firmly pressed inside the mould, by the aid of the hand, or chiefly the thumb. The chief care is to get an even thickness of material everywhere. It can be put in in small flat squares, or in rolls, but where two pieces come together the edges should be deeply scratched with a pointed instrument, so as to get perfect cohesion. The edges are wetted with slip before being put together. If care is not observed, the joints will open in firing. When the pressing is completed, the clay is allowed to become firm enough to handle, then the piece is taken out of the mould and placed on a slatted shelf to dry slowly, Slow drying is essential.

As stated, this pressing process allows of large pieces being made and, as will be understood, there is no limit to the decoration in relief that the piece can have if the mould is prepared accordingly.

Considerable shrinkage occurs when firing large pieces, this being accompanied by some risk of distortion or other injury. To obviate this it is the practice with large work to incorporate what is known as "grog" with the new clay. Grog is simply some of the same clay, fired, then ground to powder.

When the piece is of a size or shape that requires it to be made in parts, the pieces are first allowed to dry, then carefully fitted together. When the fitting is nicely adjusted, the surfaces to come together are first scratched then wetted with gum water (gum arabic). They are then given a thin coat of slip, and at once put together. As slip sets quickly, the work must be expeditiously done. The slip can be made a little slower in setting, however, by mixing a little gum with it.

Casting pieces of fine porcelain is a process of which little is heard, but M. Taxile Doat of the Royal Manufactory of Sèvres speaks highly of it, considering it well suited for pieces of all sizes, from the smallest egg-shell ware to those of great size and bulk. It is particularly suited for the amateur, being, as this noted artist says, "the triumph of the novice and the joy of beginners." *

As will be gathered the art of "throwing" (on the potters' wheel) is not requisite. Taking articles of simple form first, the process is as follows. First there have to be prepared plaster moulds suited for the pieces to be produced, and if these are of simple form and small size the moulds would have sections such as Figs. 170 and 171,

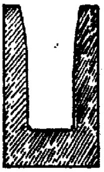


FIG. 170.

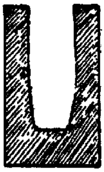


FIG. 171.

being simply plaster cups of suitable interior form. The material used is always porcelain slip, this and nothing else. A suitable quantity of this is prepared and put into a jug (having a good lip for pouring), or a spouted pot. The vessel, whichever is used, must

* 'Grand Feu Ceramics,' by Taxile Doat, a valuable and highly instructive treatise on the art of producing the highest class pottery and porcelain ware and dealing with all processes in practical detail.

hold about double as much as the mould. The slip should just previously be passed through a brass wire mesh sieve No. 120. The slip, when in the jug, is gently stirred with a flat wooden stirrer, partly to ensure that the mixture is not settled, but chiefly to cause all air to rise out of it. Some care is needed in mixing the slip as it must be neither too thin nor too thick. It should be almost pasty, having just sufficient water to make it fluid. The consistence of thick cream would be about right, but trials can be made with little trouble, and once the thickness is known, the difficulty is at an end.

Having the slip ready in the jug, it is poured into the mould to quite fill it. The mould at once begins to absorb water, therefore the jug is held ready to add more slip to keep the mould full. As the mould abstracts the water it will be seen that a deposit of paste forms on the walls, becoming thicker and thicker, and when it is judged to be sufficient, the mould is gently tilted over and the liquid slip poured out. This leaves the solid coating of thick slip remaining on the walls of the mould, and it should now be left about 24 hours, when the paste will be found to have slightly shrunk away from the mould, and it is firm enough to be carefully removed. The vase is now made, and only requires to be put away to dry. Great care has to be used in pouring out the liquid slip, as a jerk or light blow will spoil results. Any slip left on the rim of the mould after pouring is removed. The mould only requires drying in gentle heat, or in the air, to be ready for use again.

To cast vases or vessels of a shape that cannot be drawn away from a simple mould, it becomes necessary to have the mould in two or more pieces (usually with perpendicular joints) these pieces being, of course, accurately fitted, and held together with tightly tied cords, while the casting is in operation. The liquid can be poured in, as just described, but what is found to be a better plan for general purposes is to fill the moulds from the bottom with a simple apparatus as Fig. 172. This, it will be seen, consists of a zinc tank fixed up on a shelf or stand, its funnel-shaped bottom being just above the level of the top of the mould. From the bottom a lead or zinc pipe is carried, with cocks inserted, as shown. The use of iron, even iron rivets, should be avoided.

The chief detail of Fig. 172 is the method of securing the mould over

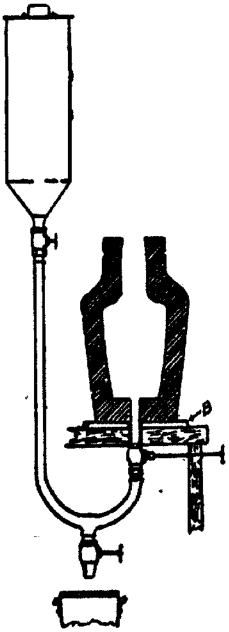


FIG. 172.

the bench inlet of the U pipe, through which the slip comes. A circular plate of beeswax about ½ in. thick is placed here, coming round the opening (and marked B in the figure), this being cemented with wax slightly

softened. If necessary a roll of clay can be pressed round the base of the mould, or a ring of clay arranged to come beneath the mould on the wax. For amateur purposes the wax might be dispensed with, a cord or ring of clay coming beneath the mould on the bench. The process, when all is ready, is very simple. The slip, passed through a sieve (No. 120), is poured into the tank and first allowed to rest a little while, then gently stirred with a wooden stirrer, then allowed to rest again for a few minutes. Before casting let the tank be sharply rapped with a piece of wood and this will finally displace any globules of air remaining in the slip. Assuming all taps to be closed, the one over the pail remains closed until the casting is finished. First open the cock nearest the mould, then the one nearest the tank, letting the latter remain open until the mould is quite full of slip. Now close this cock and re-open it gradually, just sufficient to make up the volume which is reduced by the mould absorbing water. The collection of paste thickening on the edge of the mould can be easily watched, and when it is of sufficient thickness the cock near the tank is quite closed and the one over the pail opened. This empties the mould of liquid slip, which can be put back into the tank, if further casting is to be proceeded with. The mould should be left in position about twenty to thirty minutes then it may be very carefully lifted and placed somewhere to rest for 24 hours. A heavy mould can be lifted by means of ropes and pulleys. If further casting is to be done, it can now be proceeded with, first stirring the slip in the tank, and the process described is repeated; if not, then the tank and pipes are emptied and well washed out.

The casting may be ready to have the parts of the mould removed in two days, and it will then be found to have a projecting piece of paste on its bottom where the slip flowed into the mould. This is at once removed and the vase carefully placed on a bench or shelf (sprinkled with fine sand) to harden. Great care is needed in handling the work at this time, in fact it should not be touched with the hands. If the bottom is rough or imperfect in the centre, as it probably will be, this may be bored or turned out with a suitable tool, and a new piece of dried clay made to accurately fit it, this being cemented in with slip. To finally finish the casting, it may be turned on a wheel, or it may be cleaned by hand with fine sand-paper. It is now ready for decorating. It may be added that, for best results, all moulds should be made to form a false rim to the vase being cast. This ensures the true rim having a sufficient settlement of material to give a sufficient thickness, which could not be ensured if the true rim came at the top of the mould. This false rim (or it might be called extension of the neck) of the vase is left on until the whole piece is dry, then when being turned or finished, it is removed with a knife or a turning tool. This false rim, or rather the provision for it in the mould, is the upper sloping part of the neck shown in Fig. 172.

PRESERVING AND PROTECTING

FOODS, WOODS, METALS, STONE, AND OTHER PERISHABLE MATERIALS.

(*See also* FIREPROOFING, JAPANNING, LACQUERING, PAINTING, WATERPROOFING, ETC.)

Beer.—(1) Acid sulphite of lime is recommended to be added to beer which has to be kept for a length of time in warm places, or to undergo transmarine exportation; 1 gal. of the aqueous solution (commercial) is added to 1000 gal. beer. (2) Lockwood makes a condensed beer thus:—Beer or stout is taken when fit for drinking, and evaporated in a vacuum pan until much of the water and alcohol is distilled away, and the liquor is reduced to a thick viscous fluid. The alcohol and water pass off in vapour, which is condensed in a receiver attached to the vacuum pan, and the alcohol is obtained by redistilling. This alcohol may be re-mixed with the condensed beer. The beer is reduced to $\frac{1}{8}$ or $\frac{1}{12}$ of its bulk, according to its strength, and as fermentation is suspended by the heat employed, the condensed mixture keeps good for any length of time in any climate. The process of re-making the beer is also simple, consisting in merely adding the bulk of water originally abstracted, and setting up fermentation by the use of a little yeast. Within 48 hours the beer may be drawn from the tap for use, or bottled; or may be bottled and charged with carbonic acid gas by an aerating machine.

Books from Insects.—In certain parts of China, the British Consul at Swatow observes, books are extremely liable to be attacked by insects. They first destroy the glue used in the backs of books, and gradually perforate the whole volume. Cockroaches, too, entirely disfigure the covers by eating away patches of the glazing.

The remedy for both these nuisances is easy. The late Dr. Hance, who had a large library, used the following recipe:—

Corrosive sublimate .	5 dr.
Creosote	60 drops.
Rectified spirit . . .	2 lb.

This mixture, a violent poison, he applied with a brush in the joint of the book at every 6 or 7 pages, and, as a preventive of the ravages of cockroaches, he varnished the cover of the book with a thin clear spirit-varnish. In binding books, it would be only necessary to add a small quantity of the above mixture to the glue used, and to give a coating of spirit-varnish to the cover, to secure complete protection from the attacks of insects of all kinds.

Botanical Specimens.—*Dried Plants.*—Dried plants are apt to be destroyed by insects, and large collections would soon become the prey of the larvæ of *Anobium*, *Ptinus*, *etc.*, were not the precaution taken to protect them against the attacks of these pests.

Certain persons are content to keep their plants in tightly closed cases in which they place phenic acid, camphor, or oil of thyme. Others, once or twice a year, place their packages of plants in a box especially constructed for the purpose, and therein impregnate them with the vapor of sulphide of carbon. How dangerous it is to handle this substance is well known, and it should be used with great caution. The sulphide box should be lined with zinc, and should be closed hermetically by a well-adjusted cover, whose prominent flange enters a gutter, which may be filled with water, and which is affixed to the upper part of the box. After placing a vessel containing a certain quantity of sulphide of carbon at the bottom of the box, the packages are put in place, each being partially opened, so that the vapour disengaged may penetrate everywhere. After the box is closed, it should remain so for several days, after which the cover is

removed, and the packages are exposed to the air until the odour of the sulphide has entirely disappeared. There is a process of preservation which is more generally employed, and which consists in immersing the specimens in the following solution :—

75 per cent. alcohol . .	1 qt.
Bichloride of mercury .	1¼ oz.

This liquid is a very violent poison, so the use of it requires great precaution. The following formula is sometimes preferred, because the sublimate preserves its properties more intact:—

90 per cent. alcohol . .	1 qt.
Water	2¼ oz.
Bichloride of mercury .	1¼ oz.
Muriate of ammonia . .	¾ oz.

The bichloride is dissolved in the alcohol, the muriate in the water, and the two solutions are mixed.

The plants are immersed in the liquid as follows: A deep porcelain plate of rectangular form, and a little larger and wider than the herbarium paper, is filled with the solution and placed upon a table between a package of plants to be poisoned, and a package of driers. Then the tickets are detached from the first specimen, so that they may not be ruined by a stay in the alcohol, and, as a greater precaution, in order to prevent any soiling contact, they are fixed with pins so that they project externally upon a wrapper. A good supply of wrappers should be within reach. This wrapper thus prepared is placed upon a drier, and then, with wooden or whalebone nippers, *a*, Fig. 173, the specimens are seized and immersed in the liquid. Nippers made of metal should never be used for this purpose. The form figured is the one adopted at the Museum of Natural History, and can be easily made by any one for himself.

After the specimens have remained in the liquid for a short time, they are taken out with the nippers and allowed to drain; then they are placed in the cover, which is closed and covered with a drier. The same operation is performed on the rest of the specimens. As soon as a large enough package has been formed it is put in a well-aired place, so as to permit of the evaporation of the alcohol. At the end of 24 hours it is necessary to replace the damp driers by dry ones. A longer stay in them would blacken the specimens.

It must not be thought that the specimens thus prepared are for ever proof against the attack of insects. The herbarium should be often inspected, and a few drops of preservative liquid be thrown upon such specimens as are beginning to be attacked. This operation may be very easily performed with the bottle represented in *b*. This is closed with a rubber stopper, through which pass two glass tubes, one for the passage of the liquid and the other for the entrance of air.

Certain families of plants are much more sought after than others by insects. As a general thing, fleshy plants and those that contain starch are the first ones eaten; the grasses, ferns, and mosses, on the contrary, are very rarely attacked. After the plants have been poisoned, it only remains to arrange them in the herbarium. To this effect, they are fixed upon simple sheets of strong, sized paper, in such a way that they will hold well. Thus prepared they are put in wrappers. The mean dimensions of the mounting paper are 12 × 11 in.

For fixing the specimens use small straps of gummed paper arranged here and there in such a way (*c*, Fig. 174) as to hold all the parts, without, however, concealing them. Instead of straps some persons use pins, but the use of these is more difficult, and they have the drawback of breaking the delicate parts of plants by their contact. The specimens must not be glued to the paper, but should be detachable at will, so that they can be thoroughly examined when necessary. Several species should never be fixed upon the same sheet.

Large specimens, the lichens, with their support, and certain fungi can

be fixed only upon very strong paper or even upon cardboard, and it is sometimes indispensable to sew them on with cord. In order to prevent them from injuring the neighbouring plants in the package, good cushions of soft paper should be interposed. In all cases sufficient space should be reserved at the bottom of the sheet for the reception of the labels. To the left is placed that of the collector or of the person from whom the specimen was received. This label should always be carefully preserved, for it is the one that must give authority in the case of doubt. It should bear the number and the notes taken in the memorandum book. When it is a question of *exsiccati*, that is to say, of collections of which several examples exist, the numbers permit of easily finding the names of the plants when the latter are described and published. To the right is placed a label by itself sufficiently large to allow bibliographic data and observations to be added to the name. The flowers and fragments that become detached during the preparation of the specimens must not be registered, but should be preserved

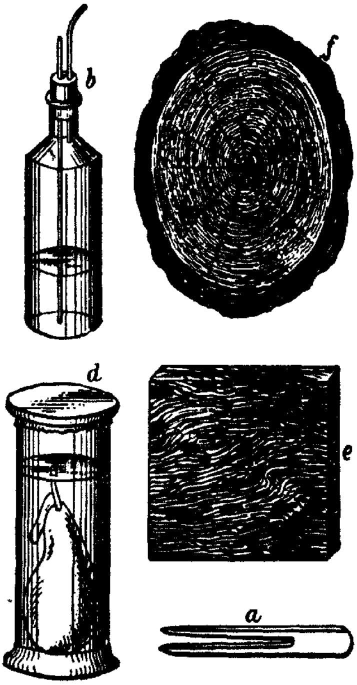


FIG. 173.

in small envelopes, and whenever it is desired to make an analysis, it is better to use them than to injure one's collection. The sheets, filled with specimens, are placed in wrappers, and it only remains to classify them by families and put them in packages, which should be arranged in tight cases in a dry place, and where the wrapper should be glued a small conspicuous ticket bearing the name of the species. This renders researches much easier.

Conspicuous tickets are also used for the genera, but these are fixed upon simple sheets, so that they can be easily shifted. They must be very distinct from the preceding. They

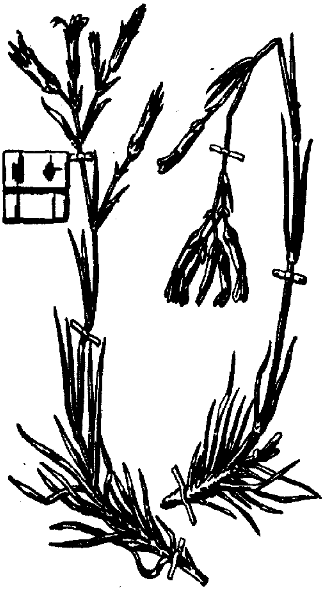


FIG. 174.

temperature is as equable as possible. Care should be taken to allow nothing to enter the room devoted to the collection that could attract insects, and never to allow plants to enter it that have not first been poisoned. Several sheets on which are mounted species belonging to the same genus may be enclosed in the same wrapper. To the upper right-hand corner of the may, for example, be made longer, and of a different colour. They are usually affixed to the middle of the sheet. The family ticket should be larger still, and also of another colour It is fixed to the left of a simple sheet.

The herbarium packages should not be too bulky. They are kept between cardboards, fastened together with straps.

An excellent measure taken at the herbarium of the Paris Museum consists in placing the species, according to their country, in wrappers bearing labels of various colours, corresponding to the 5 parts of the world. White indicates European species, yellow represents those of Asiatic origin, blue is for Africa, green for America, and red for Oceania. This arrangement permits of easily finding the species in which one is interested when he is making researches upon the flora of a region. Besides, it shows at a glance the geographical distribution of each species, genus, and family.

Fruits.—A collection of fruits is the indispensable complement of the herbarium. To render work easier it is as well to place it as near the latter as possible.

After well washing the freshly-gathered fruits in order to free them from foreign matter (care being taken during the operation not to rub them in such a way as to deprive them of certain important characters, such as colour, villosity, etc.), they are put into jars containing alcohol and water. These fruits should carry a securely fastened parchment label, on which is written the number of the memorandum book. The lead pencil has the advantage over ink that the writing does not become effaced in alcohol; yet for greater safety, it is preferable to form the numbers with a punch. The cost of a set of punches is quite justified by the security offered by the tickets that it permits of making.

If a person is travelling, and wishes to ship the fruits, he will merely have to close the jars tightly with good corks, covered with a thick layer of bottle wax. Sealing wax dissolves in alcohol, and it is therefore very important to have corks that adjust themselves perfectly to the vessel if one wishes the corking not to be defective. The jars should be carefully packed to prevent breakage. They should be accompanied with a catalogue bearing notes from the memorandum book opposite the numbers.

When it is desired to arrange the fruits, it is often necessary to change the alcohol, which, in certain cases, rapidly darkens. The liquid should be changed several times, until it remains of sufficient limpidity.

A large number of systems have been devised for closing the jars. A cork stopper, when of good quality, has the advantage of being easy to insert and extract, and that is to be taken into consideration if it is necessary to examine the specimens often. At the museum are used jars with a lip, which are covered with glass discs, held by glaziers' putty. After the latter is dry, a piece of bladder is glued to the disc, and its edges are tied around the neck with a string. Finally, the whole is covered with thin tin foil. There is nothing further to do but to put a label on the jar bearing the name of the fruit, its origin, and the name of the collector. As the same number is carried by the specimen in the herbarium and the jar containing the fruit, it permits of easily bringing together these parts when it is desired to study them.

Dry fruits are simply put into glazed boxes or into bags or jars.

The classification of the collection of fruits should be done in the same order as that of the herbarium.

Wood.—Specimens of woods should be kept in a separate room from that of the herbarium. They usually contain numerous insects' eggs, and, from time to time, they should be put into the sulphide of carbon box. They should, as far as possible, be of uniform dimensions, and, in order that the structure of the wood may be well seen, the same species should be represented by longitudinal and transverse sections, *e*, *f*, Fig. 173. Specimens of wood should be labelled and classified with the same care and in the same order as the other collections.

Classification of Collections.—It is indispensable to classify collections and to catalogue them, so that the objects that they contain may be easily found, and one may know what he

owns. The catalogue should be numbered, and the numbers placed upon the tickets of the genera and species to which they correspond. This considerably facilitates researches. In order to avoid beginning a new numbering every time that additions are made, it is necessary to take works for one's guide that, as far as possible, contain the total number of genera or species of the region that one has taken as a limit. ('La Nature').

Canning and Preserving on a Small Scale. *Principles.*—In the preservation of foods by canning, preserving, etc., the most essential things in the processes are the sterilisation of the food and all the utensils, and the sealing of the sterilised food to exclude all germs.

Molds and Molding.—In the work of canning, preserving, and jelly making, it is important that the food shall be protected from the growth of molds, as well as the growth of yeasts and bacteria.

To kill mold-spores, food must be exposed to a temperature of from 150° F. to 212° F. After this it should be kept in a cool, dry place, and covered carefully that no floating spore can find lodgment on its surface.

Sterilization.—Since air and water, as well as the foods, contain bacteria and yeasts, and may contain mold-spores, all utensils used in the process of preserving foods are liable to be contaminated with these organisms. For this reason all appliances, as well as the food, must be sterilised.

Stewpans, spoons, strainers, etc., may be put on the fire in cold or boiling water, and boiled 10 or 15 minutes. Tumblers, bottles, glass jars, and covers should be put in cold water and heated gradually to the boiling point, and then boiled for 10 or 15 minutes. The jars must be taken one at a time from the boiling water, at the moment they are to be filled with the boiling food. The work should be done in a well swept and dusted room, and the clothing of the workers and the towels used should be clean. The food to be sterilised should be perfectly sound and clean.

In canning fruits it is well to remember that the product is more satisfactory if heated gradually to the boiling point and then cooked the given time.

Utensils Needed for Canning and Preserving.—In preserving, canning, and jelly making, iron or tin utensils should never be used. The fruit acids attack these metals and so give a bad colour and metallic taste to the products. The preserving kettles should be porcelain lined, enamelled, or of a metal that will not form troublesome chemical combinations with fruit juices. The kettles should be broad rather than deep, as the fruit should not be cooked in deep layers. Nearly all the necessary utensils may be had in some ware not subject to chemical action. A list of the most essential articles follows:—

Two preserving kettles, 1 colander, 1 fine strainer, 1 skimmer, 1 ladle, 1 large-mouthed funnel, 1 wire frying basket, 1 wire sieve, 4 long-handled wooden spoons, 1 wooden masher, a few large pans, knives for paring fruit (plated if possible), flat-bottomed clothes boiler, wooden or willow rack to put in the bottom of the boiler, iron tripod or ring, squares of cheese cloth. In addition, it would be well to have a flannel straining bag, a frame on which to hang the bag, a syrup gauge and a glass cylinder, a fruit picker, and plenty of clean towels.

The regular kitchen pans will answer for holding and washing the fruit. Mixing bowls and stone crocks can be used for holding the fruit juice and pared fruit. When fruit is to be plunged into boiling water for a few minutes before paring, the ordinary stewpans may be employed for this purpose.

If canning is done by the oven process, a large sheet of asbestos, for the bottom of the oven, will prevent the cracking of jars.

The wooden rack, on which the bottles rest in the washboiler, is made

in this manner. Have two strips of wood measuring 1 in. high, 1 in. wide, and 2 in. shorter than the length of the boiler. On these pieces of wood tack thin strips of wood that are 1½ in. shorter than the width of the boiler. These cross-strips should be about 1 in. wide, and there should be an inch between two strips. This rack will support the jars and will admit the free circulation of boiling water about them. Young willow branches, woven into a mat, also make a good bed for bottles and jars.

The wire basket is a saver of time and strength, Fig. 175. The fruit to

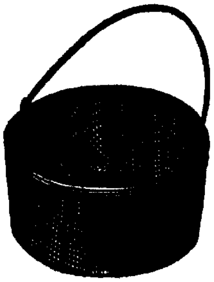


FIG. 175.

be peeled is put into the basket, which is lowered into a deep kettle partially filled with boiling water. After a few minutes the basket is lifted from the boiling water, plunged for a moment into cold water, and the fruit is ready to have the skin drawn off.

A strong wire sieve, Fig. 176, is a necessity when purées of fruit are to be made. These sieves are known as purée sieves. They are made of strong wire, and in addition, have supports of still stronger wire.

A fruit pricker, Fig. 177, is easily made and saves time. Cut a piece ½ in. deep from a broad cork; press through this a dozen or more coarse darning needles; tack the cork on a piece of board. Strike the fruit on the bed of needles, and you have a dozen holes at once. When the work is finished, remove the cork from the board, wash and dry thoroughly. A little oil on the needles will prevent rusting. With needles of the size suggested there is little danger of the points breaking, but it is worth remembering that the use of pricking machines was abandoned in curing prunes on a commercial scale in California because the steel needles broke and remained in the fruit.

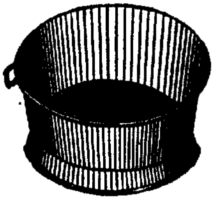


FIG. 176.

FIG. 177.

A wooden vegetable masher, Fig. 178, is indispensable when making jellies and purées.

A syrup gauge and glass cylinder, Fig. 179, are not essential to preserving, canning, and jelly making, but they are valuable aids in getting the right proportion of sugar for fruit or jelly. The syrup gauge costs about 2s. and the cylinder about 1s. A lipped cylinder that holds a little over a gill is the best size.

Small iron rings, such as sometimes come off the hub of cart wheels, may be used instead of a tripod for slightly raising the preserving kettles from the hot stove or range.

To make a flannel straining bag, take a square piece of flannel (27 by 27 in. is a good size), fold it to make a three-cornered bag, stitch one of the sides, cut the top square across, bind

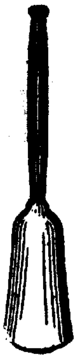


FIG. 178.

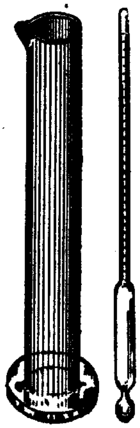


FIG. 179.

the opening with strong, broad tape, stitch on this binding four tapes with which to tie the bag to a frame.

To use this bag, tie it to a strong frame or to the backs of two kitchen chairs. If the chairs are used, place some heavy articles in them; or the bag may hang on a pole (a broom handle) which rests on the backs of the chairs. A high stool turned upside down makes a good support for the bag. Put a bowl on the floor under the bag, then pour in the fruit juice, which will pass through comparatively clear.

Before it is used, the bag should be washed and boiled in clear water.

Selection and Preparation of the Fruit.—The selection of fruit is one of the first steps is obtaining successful results. The flavour of fruit is not developed until it is fully ripe, but the time at which the fruit is at its best for canning, jelly making, etc., is just before it is perfectly ripe. In all soft fruits the fermentative stage follows closely upon the perfectly ripe stage; therefore it is better to use under-ripe rather than over-ripe fruit. This is especially important in jelly making for another reason also: in over-ripe fruit the pectin begins to lose its jelly-making quality.

All fruits should, if possible, be freshly picked for preserving, canning and jelly-making. No imperfect fruit should be canned or preserved. Gnarly fruit may be used for jellies or marmalades by cutting out defective portions. Bruised spots should be cut out of peaches and pears. In selecting small-seeded fruits, like berries, for canning, those having a small proportion of seed to pulp should be chosen. In dry seasons berries have a larger proportion of seeds to pulp than in a wet or normal season, and it is not wise to can or preserve such fruit unless the seeds are removed. The fruit should be rubbed through a sieve that is fine enough to keep back the seeds. The strained pulp can be preserved as a purée or marmalade.

When fruit is brought into the house, put it where it will keep cool and crisp until you are ready to use it.

The preparation of fruit for the various processes of preserving is the second important step. System will do much to lighten the work.

Begin by having the kitchen swept and dusted thoroughly, that there need not be a large number of mold spores floating about. Dust with a damp cloth. Have plenty of hot water and pans in which jars and utensils may be sterilised. Have at hand all necessary utensils, towels, sugar, etc.

Prepare only as much fruit as can be cooked while it still retains its colour and crispness. Before beginning to pare fruit, have some syrup ready, if that is to be used, or if sugar is to be added to the fruit, have it weighed or measured.

Decide upon the amount of fruit you will cook at one time, then have two bowls—one for the sugar and one

for the fruit—that will hold just the quantity of each. As the fruit is pared or hulled, as the case may be, drop it into its measuring bowl. When the measure is full, put the fruit and sugar in the preserving kettle. While this is cooking, another measure may be prepared and put in the second preserving kettle. In this way the fruit is cooked quickly and put in the jars and sealed at once, leaving the pans ready to sterilise another set of jars.

If the fruit is to be preserved or canned with syrup, it may be put into the jars as fast as it is prepared. As soon as a jar is full, pour in enough syrup to cover it.

If several people are helping and large kettles are being used for the preserving, or where fruit (like quinces and hard pears) must be first boiled in clear water, the pared fruit should be dropped into a bowl of cold water made slightly acid with lemon juice (one tablespoonful of lemon juice to a quart of water). This will keep the fruit white.

All large, hard fruit must be washed before paring. Quinces should be rubbed with a coarse towel before they are washed.

If berries must be washed, do the work before stemming or hulling them. The best way to wash berries is to put a small quantity into a colander and pour cold water over them; then turn them on a sieve to drain. All this work must be done quickly that the fruit may not absorb much water.

Do not use the fingers for hulling strawberries. A simple huller can be bought for a few pence.

If practicable, pare fruit with a silver knife, so as not to stain or darken the product. The quickest and easiest way to peel peaches is to drop them into boiling water for a few minutes. Have a deep kettle a little more than half full of boiling water; fill a wire basket with peaches; put a long-handled spoon under the handle of the basket and lower into the boiling water. At the end of three minutes, lift the basket out by slipping the spoon under the handle. Plunge the basket for a moment into a pan for cold water. Let the peaches drain a minute, then peel. Plums and tomatoes may be peeled in the same manner.

If the peaches are to be canned in syrup, put them at once into the sterilised jars. They may be canned whole or in halves. If in halves, remove nearly all the stones or pits. For the sake of the flavour, a few stones should be put in each jar.

When preparing cherries, plums or crab apples for canning or preserving, the stem or a part of it may be left on the fruit.

When preparing to make jelly, have ready the cheese-cloth strainer, enamelled colander, wooden spoons, vegetable-masher, measures, tumblers, preserving-kettles and sugar.

If currant jelly is to be made, free the fruit from leaves and large stems. If the jelly is to be made from any of the other small fruits, the stems and hulls must be removed.

When the jelly is to be made from any of the large fruits, the important part of the preparation is to have the fruit washed clean, then to remove the stem and the blossom end; nearly all the large fruits are better for having the skin left on. Apples and pears need not be cored. There is so much gummy substance in the cores of quinces that it is best not to use this portion in making fine jelly.

Making Syrup for Use in Canning and Preserving.—1 pint sugar and 1 gill of water gives syrup of 40° density; use for preserved strawberries and cherries.

1 pint sugar and ½ pint water gives syrup of 32° density.

1 pint sugar and 3 gills water gives syrup of 28° density; use either this or the preceding for preserved peaches, plums, quinces, currants, etc.

1 pint sugar and 1 pint water gives syrup of 24° density; use for canned acid fruits.

1 pint sugar and 1½ pint water gives syrup of 17° density.

1 pint sugar and 2 pints water gives syrup of 14° density; use either of these two light syrups for canned pears, peaches, sweet plums, and cherries, raspberries, blueberries and blackberries.

The lightest syrups may be used for filling up the jars after they are taken from the oven or boiler. The process of making a syrup is very simple, but there are a few points that must be observed if syrup and fruit are to be perfect. Put the sugar and water in the saucepan and stir on the stove until all the sugar is dissolved. Heat slowly to the boiling-point and boil gently without stirring. The length of time that the syrup should boil will depend how rich it is to be. All syrups are better for boiling from 10 to 30 minutes. If rich syrups are boiled hard, jarred or stirred, they are apt to crystallise. The syrup may be made a day or two in advance of canning time. The light syrups will not keep long unless sealed, but the heavy syrups keep well if covered well.

Canning Fruit.—This method of preserving fruit for home use is from all points the most desirable. It is the easiest and commonly considered the most economical and the best, because the fruit is kept in a soft and juicy condition in which it is believed to be easily digested. The wise housekeeper will can her principal fruit supply, making only enough rich preserves to serve for variety and for special occasions.

The success of canning depends upon absolute sterilisation. If the proper care is exercised there need be no failure, except in rare cases, when a spore has developed in the can. There are several methods of canning; and while the principle is the same in all methods, the conditions under which the housekeeper must do her work, may, in her case, make one method more convenient than another. For this reason three will be given which are considered the best and easiest. These are: Cooking the fruit in the jars in an oven; cooking the fruit in the jars in boiling water; and stewing the fruit before it is put in the jars. The quantity of sugar may be increased if the fruit is liked sweet.

It is most important that the jars, covers, and rubber rings be in perfect condition. Examine each jar and cover to see that there is no defect in it. Use only fresh rubber rings, for if the rubber is not soft and elastic the sealing will not be perfect. Each year numbers of jars of fruit are lost because of the false economy in using an old ring that has lost its softness and elasticity. Having the jars, covers, and rings in perfect condition, the next thing is to wash and sterilise them. Have two pans partially filled with cold water. Put some jars in one, laying them on their sides, and some covers in the other. Place the pans on the stove where the water will heat to the boiling-point. The water should boil at least 10 or 15 minutes. Have on the stove a shallow milk pan in which there is about 2 in. of boiling water. Sterilise the cups, spoons and funnel, if you use one, by immersing in boiling water for a few minutes.

When ready to put the prepared fruit in the jars slip a broad skimmer under a jar and lift it and drain free of water. Set the jar in the shallow milk pan and fill to overflowing with the boiling fruit. Slip a silver-plated knife or the handle of a spoon around the inside of the jar that the fruit and juice may be packed solidly. Wipe the rim of the jar, dip the rubber ring in boiling water and put it smoothly on the jar, then put on the cover and fasten. Place the jar on a board and out of a draught of cold air. The work of filling and sealing must be done rapidly, and the fruit must be boiling hot when it is put into the jars. If screw covers are used it will be necessary to tighten them after the glass has cooled and contracted. When the fruit is cold wipe the jars with a wet cloth, paste on the labels, if any, and put the jars on shelves in a cool, dark closet.

In canning, any proportion of sugar

may be used, or fruit may be canned without the addition of any sugar. However, that which is designed to be served as a sauce should have the sugar cooked with it. Fruit intended for cooking purposes need not have the sugar added to it.

Juicy fruits, such as berries and cherries, require little or no water. Strawberries are better to have no water added to them. The only exception to this is when they are cooked in a heavy syrup.

Raspberries.—12 qt. of raspberries, 2 qt. of sugar.

Put 2 qt. of the fruit in the preserving kettle; heat slowly on the stove; crush with a wooden vegetable masher; spread a square of cheese cloth over a bowl, and turn the crushed berries and juice into it. Press out the juice which turn into the preserving kettle. Add the sugar and put on the stove; stir until the sugar is dissolved. When the syrup begins to boil add the remaining 10 qt. of berries. Let them heat slowly. Boil 10 minutes, counting from the time they begin to bubble. Skim well while boiling. Put in cans and seal as directed.

Raspberries and Currants.—10 qt. of raspberries, 3 qt. of currants, 2½ qt. of sugar.

Heat, crush and press the juice from the currants and proceed as directed for raspberries.

Blackberries.—The same as for raspberries.

Currants.—12 qt. of currants, 4 qt. of sugar. Treat the same as for raspberries.

Gooseberries.—6 qt. of berries, 1½ qt. of sugar, 1 pint of water.

For green gooseberries dissolve the sugar in water, then add the fruit and cook 15 minutes. Ripe gooseberries are to be treated the same as the green fruit, but use only half as much water. Green gooseberries may also be canned the same as rhubarb.

Blueberries.—12 qt. of berries, 1 qt. of sugar, 1 pint of water.

Put water, berries, and sugar in the preserving kettle; heat slowly. Boil 15 minutes, counting from the time the contents of the kettle begin to bubble.

Cherries.—6 qt. of cherries, 1½ qt. of sugar, 1 pint of water.

Measure the cherries after the stems have been removed. Stone them or not, as you please. If you stone them be careful to save all the juice. Put the sugar and water in the preserving kettle and stir over the fire until the sugar is dissolved. Put in the cherries and heat slowly to the boiling point. Boil 10 minutes, skimming carefully.

Grapes.—6 qt. of grapes, 1 qt. of sugar, 1 gill of water.

Squeeze the pulp of the grapes out of the skins. Cook the pulp 5 minutes and then rub through a sieve that is fine enough to hold back the seeds. Put the water, skins and pulp into the preserving kettle and heat slowly to the boiling point. Skim the fruit and then add the sugar. Boil 15 minutes.

Sweet grapes may be canned with less sugar, very sour ones may have more.

Rhubarb.—Cut the rhubarb when it is young and tender. Wash it thoroughly and then pare; cut into pieces about 2 inches long. Pack in sterilised jars. Fill the jars to overflowing with cold water and let them stand 10 minutes. Drain off the water and fill again to overflowing with fresh cold water. Seal with sterilized rings and covers. When required for use treat the same as fresh rhubarb.

Green gooseberries may be canned in the same manner. Rhubarb may be cooked and canned with sugar in the same manner as gooseberries.

Peaches.—8 qt. of peaches, 1 qt. of sugar, 8 qt. of water.

Put the sugar and water together and stir over a fire until the sugar is dissolved. When the syrup boils skim it. Draw the kettle back where the syrup will keep hot but not boil. Pare the peaches, cut in halves, and remove the stones, unless you prefer to can the fruit whole.

Put a layer of the prepared fruit into the preserving kettle and cover

with some of the hot syrup. When the fruit begins to boil, skim carefully. Boil gently for 10 minutes, then put in the jars and seal. If the fruit is not fully ripe it may require a little longer time to cook. It should be so tender that it may be pierced easily with a silver fork. It is best to put only one layer of fruit in the preserving kettle. While this is cooking the fruit for the next batch may be pared.

Pears.—If the fruit is ripe it may be treated exactly the same as peaches. If, on the other hand, it is rather hard it must be cooked until so tender that a silver fork will pierce it readily.

Quinces.—4 qt. of cored, pared, and quartered quinces; 1½ qt. of sugar; 2 qt. of water.

Rub the fruit hard with a coarse, crash towel, then wash and drain. Pare, quarter and core; drop the pieces into cold water. Put the fruit in the preserving kettle with cold water to cover it generously. Heat slowly and simmer gently until tender. The pieces will not all require the same time to cook. Take each piece up as soon as it is so tender that a silver fork will pierce it readily. Drain on a platter. Strain the water in which the fruit was cooked through cheese cloth. Put 2 qt. of the strained liquid and the sugar into the preserving-kettle; stir over the fire until the sugar is dissolved. When it boils, skim well and put in the cooked fruit. Boil gently for about 20 minutes.

Crab Apples.—6 qt. of apples, 1½ qt. of sugar, 2 qt. of water.

Put the sugar and water into the preserving kettle. Stir over the fire until the sugar is dissolved. When the syrup boils skim it.

Wash the fruit, rubbing the blossom end well. Put it in the boiling syrup, and cook gently until tender. It will take from 20 to 50 minutes, depending upon the kind of crab apples.

Plums.—8 qt. of plums, 2 qt. of sugar, 1 pint of water.

Nearly all kinds of plums can be cooked with the skins on. If it is desired to remove the skin of any variety, plunge them in boiling water for a few minutes. When the skins are left on, prick them thoroughly to prevent bursting.

Put the sugar and water into the preserving kettle and stir over the fire until the sugar is dissolved. Wash and drain the plums. Put some of the fruit in the boiling syrup. Do not crowd it. Cook five minutes; fill and seal the jars. Put more fruit in the syrup. Continue in this manner until all the fruit is done. It may be that there will not be sufficient syrup toward the latter part of the work; for this reason it is well to have a little extra syrup on the back of the stove.

Stewed Tomatoes.—Wash the tomatoes and plunge into boiling water for 5 minutes. Pare and slice and then put into the preserving kettle; set the kettle on an iron ring. Heat the tomatoes slowly, stirring frequently from the bottom. Boil for thirty minutes, counting from the time that the vegetable actually begins to boil. Put in sterilised jars and seal.

Whole Tomatoes.—8 qt. of medium-sized tomatoes, 4 qt. of sliced tomatoes.

Put the pared and sliced tomatoes into a stewpan and cook as directed for stewed tomatoes. When they have been boiling 20 minutes, take from the fire and rub through a strainer. Return to the fire.

While the sliced tomatoes are cooking, pare the whole tomatoes and put them in sterilized jars. Pour into the jars enough of the stewed and strained tomato to fill all the interstices. Put the uncovered jars in a moderate oven, placing them on a pad of asbestos or in shallow pans of hot water. Let the vegetable cook in the oven for ½ hour. Take from the oven and fill to overflowing with boiling-hot, strained tomato, then seal. If there is any of the strained tomato left, can it for sauces.

Canned Fruit Cooked in the Oven.—This method of canning fruit, in the

opinion of the writer, is the one to be preferred. The work is easily and quickly done, and the fruit retains its shape, colour and flavour better than when cooked in the preserving kettle.

Cover the bottom of the oven with a sheet of asbestos, the kind plumbers employ in covering pipes. It is very cheap, and may usually be found at plumber's shops. If the asbestos is not available, put into the oven shallow pans in which there are about 2 inches of boiling water.

Sterilise the jars and utensils. Make the syrup; prepare the fruit the same as for cooking in the preserving kettle. Fill the hot jars with it, and pour in enough syrup to fill the jar solidly. Run the blade of a silver-plated knife around the inside of the jar. Place the jars in the oven, either on the asbestos or in the pan of water. The oven should be moderately hot. Cook the fruit 10 minutes; remove from the oven and fill the jar with boiling syrup. Wipe and seal. Place the jars on a board and out of a draught of air. If the screw covers are used tighten them after the glass has cooled.

Large fruits, such as peaches, pears, quinces, crab apples, etc., will require about a pint of syrup to each quart jar of fruit. The small fruit will require a little over ½ pint of syrup.

The amount of sugar in each quart of syrup should be regulated to suit the fruit with which it is to be used. The data on page will be a guide. The quantities given will not make the fruit very sweet. The quantity of sugar may be increased or diminished to suit the taste.

Canned Fruit Cooked in a Water Bath.—Prepare the fruit and syrup as for cooking in the oven.

Fill the sterilised jars and put the covers on loosely. Have a wooden rack in the bottom of a wash boiler. Put in enough warm water to come to about 4 inches above the rack. Place the filled jars in the boiler, but do not let them touch one another. Pack clean white cotton rags, or perhaps better, cotton rope, between and around the jars to prevent them from striking one another when the water begins to boil.

Draw the boiler back and take off the cover. When the steam passes off, take out one jar at a time and place in a pan of boiling water beside the boiler, fill up with boiling syrup, and seal. Put the jars on a board, and do not let cold air blow upon them. If screw covers are used, tighten them when the glass has cooled and contracted.

Canning and Preserving on a Large Scale.—Factory canning as practised in the United States is done either by the open-bath process, or closed bath, the latter, of course, offering a very much wider power of control than the former, in which the temperature is limited to that of boiling water. In the open bath process the time is taken from the point at which the water boils, and in the closed bath system from the time at which the contents of the tank reach the pre-determined temperature. The material to be canned is placed in the tins and heated to boiling point for a short time before the tins are sealed, after which they are submitted to the final cooking. The following is a summary of the usual temperatures allowed for various foods.

Apples.—Exhaust 5 minutes at 212; open-bath, 10 minutes at 212; closed-bath, 3 minutes at 240.

Cherries.—Exhaust, 7 minutes at 212; open-bath, 12 minutes at 212; closed-bath, 4 minutes at 240.

Gooseberries.—Exhaust, 7 minutes at 212; open-bath, 12 minutes at 212; closed-bath, 4 minutes at 240.

Peaches.—Exhaust, 5 minutes at 212; open-bath, 10 minutes at 212; closed-bath, 4 minutes at 240.

Pears.—Exhaust, 5 minutes at 212; open-bath, 12 minutes at 212; closed-bath, 5 minutes at 240.

Asparagus.—Exhaust, 10 minutes at 212; closed-bath, 30 minutes at 240.

Tomatoes.—Exhaust, 10 minutes at 212; open-bath, 30 minutes at 212

for 3-lb. can. Closed-bath, 10 minutes at 240 for 3-lb. can, and 8 minutes for 2-lb. can.

Meats.—Exhaust, small cans (up to 3 lb.) 10 minutes at 212, large cans (up to 6 lb.) 15 minutes at 212, 14-lb. cans, 20 minutes at 212. Closed-bath, from 5 to 45 minutes at 240, in accordance with weight.

For further information on this subject refer to the works of Schwab and Pacrette, in which very detailed instructions are to be found, for working of a canning plant, on commercial lines.

Charred Paper.—Collodion is poured over the charred paper. In a few minutes this dries, and a tough transparent coating is produced, through which the printing, etc., can be seen. Bank-notes and other documents charred by fire have been thus successfully treated. ('Scient. Amer.')

Distilled Water.—In the first place, contrary to the general opinion, condensed steam does not always furnish pure distilled water. The drip from the cylinders of steam engines is never fit for use, not being half so good as ordinary rainwater. In preparing distilled water, the directions generally given to reject the portion that first comes over should never be omitted.

The best water from which to prepare the distilled article is, in my opinion, good clear well water. Rainwater is generally well loaded with organic matter, and holds generous quantities of ammonia in solution. Ammonia, of course, distils over, and this impurity the Pharmacopœia does not permit. Prof. Lloyd once said that in order to prepare an acceptable article of distilled water from the city at Cincinnati, it was necessary to distil 3 to 4 times from an ordinary apparatus; but that now, by carrying a standpipe to the third storey of his factory, the product obtained was good.

The following procedure in distilling and storing will never fail to give satisfaction. Say the still is of 5 gal. capacity, not more than 4 should ever be distilled therein: take then 4½ gal. of good clear well water; boil violently in a bright tin vessel for 10 minutes—this drives off almost the last trace of ammonia; then introduce into the perfectly clean still; start the process; reject the first ½ gal., and save the succeeding 2½ gal.

This is to be stored as follows: Prepare an empty carboy by boring with a rat-tail file a hole in the shoulder: through this hole introduce a glass siphon, made air-tight at the point of contact with the carboy by slipping over the siphon tube a piece of rubber tubing, and on the longer arm of the siphon place another piece of rubber tubing about 4 in. long, provided with a pinchcock. Into the mouth of the carboy fit a perforated cork, holding a glass tube filled with cotton; this is to be inserted as a stopper, the tube filled with cotton acting as a vent. All the air entering the carboy will be drawn through the cotton, thus being filtered perfectly free from motes. It is these motes, or dust particles, among which the seeds of the confervæ exist that cause the ropiness which is to be avoided.

The distilled water in dropping from the mouth of the condenser into the receiver, as a rule, becomes contaminated with air motes, and unless these be removed before the water is finally deposited in the carboy, confervoid growths will appear.

To accomplish this, the distilled water must be brought to a boil in a bright tin vessel, the warm carboy thoroughly rinsed with it, and when, at last, the container is full, insert the perforated stopper carrying the tube filled with cotton; start the siphon, and now, if the stopper is not removed, the entire contents may be used, as required, and not a single fleck will form therein. (J. N. Hurty.) (*See also* DISTILLING, Vol. I.)

Eggs.—Some months ago there appeared in the bulletin, issued by the Italian Minister of Agriculture, the

result of a series of experiments by Dr. Campanini, intended to ascertain the best means of preserving eggs. Dr. Campanini, after reviewing the best known means of preserving eggs—by salt water, lime water, silicate of potash, vaseline, and cold storage—described his experiments, for which he claimed better results than all others. His theory is that to preserve eggs some system must be adopted that will absolutely prevent the exchange between the air outside and that inside the egg, it being this continual change that causes putrefaction. Dr. Campanini selected perfectly fresh eggs and covered them with lard so as effectually to stop up all the pores. The shells were thus rendered impermeable, the exchange of air was prevented, and the obstruction of the pores not permitting the evaporation of the water, there was no loss of weight. When properly coated with lard—not too thickly—the eggs are put in baskets or boxes upon a bed of tow or fine odourless shavings, and so arranged that there will be no point of contact between them—otherwise a mould will develop and putrefaction result. By this process Dr. Campanini kept a quantity of eggs for a whole year—through a very hot summer and a very cold winter—and they were perfectly preserved. He says that two pennyworth of lard sufficed to coat 100 eggs, and that any one could easily prepare that number of eggs in one hour's time.

Fish.—Before alluding to recent processes for preserving fish in a fresh state, some space may be devoted to the ordinary methods of curing fish.

Herrings.—The fish are spread on a floor, and sprinkled with salt; when sufficiently salted, they are thrown into large vats, and washed. Each fish is then threaded through the gills on long thin spits holding 25 each. These are hung upon trestles in the smoking-room, where fires of oak-boughs are kept smouldering. For "bloaters," to be consumed in England, the smoking lasts about 24 hours; "red-herrings" for export are salted more, and are smoked for 3 or 4 to 40 days, usually about 14 days. "Kippers" are taken while fresh, and split up. They are then washed, and thrown into vats with plenty of salt for a few minutes; finally they are spread out on tenter-hooks, on racks, and hung up for 8 hours' smoking.

Oysters.—A method of preserving oysters is adopted by the Chinese. The fish are taken from the shells, plunged into boiling water for an instant, and then exposed to the sun till all the moisture is removed. They remain fresh for a long time, and retain their full flavour. Only the fattest can be so treated. Oysters are also largely "canned," much in the same way as salmon.

Sardines.—The beheaded and cleaned fish are spread upon sieves, and plunged for 1 or 2 minutes beneath the surface of boiling oil in coppers. After draining a little, the fish are packed closely in tin boxes, which are filled up with pure cold oil, and soldered. The quality deteriorates with every immersion, owing to the matters disengaged by the boiling oil, and the coppers need frequent replenishing with oil.

Shrimps.—To preserve shrimps in a dried state, they are boiled for ½ hour with frequent sprinkling of salt; then spread out on hard dry ground, with frequent turning, to dry and bleach for 3 or 4 days. They are then trampled to remove the shells, and are winnowed and bagged.

Refrigeration.—This process is applicable to all kinds of fish. (*See* REFRIGERATION.)

Flowers.—Roses may be cut in the summer and autumn months and so treated that they may be brought out in full bloom during the flowerless months of winter. Gather the flowers in bud and when quite dry, as any trace of damp will quite spoil the results. Dip the ends of the stems in hot wax, then carefully tie the petals with silk thread to keep them in place. When this is done, carefully

wrap up each bloom in fine tissue paper, tying up the ends of the wrappers with thread. Then lay the tied-up blooms in air-tight tin boxes, packing them so that they are not crushed together in any way.

Finally put away the boxes in a cupboard which keeps of fairly even temperature, but not too warm. When required for use, the buds must be taken most carefully from the box (as they are very brittle when dry), and after removing the tissue paper and the silken bands tying up the petals, the stems are cut with a sharp pair of scissors just above the waxed ends, and then placed in water for about 5 minutes. The blooms are then placed in a basin of fresh cold water into which has been thrown a handful of salt, and the basin put in a warm cupboard for a few hours, when the blooms will develop much of their original beauty. Though not always successful, this process will nevertheless give a fair proportion of blooms at a time of year when they are very scarce. Success depends on only storing perfectly dry buds, and on not letting the petals be touched by water, during the process of revival.

Food.—(*See* "Canning and Preserving" (page 445).

Fruit, Grain, and Vegetables. *Desiccation.*—The simplest form of desiccation is by ordinary sun- and wind-drying, as conducted in haymaking. The next step is by radiated sun-heat, as in coffee-drying; a further advance is made by the application of artificial heat, as in hop-drying and tea-drying. The primary object in all these cases is the removal of the water mechanically present, and without whose presence fungoid growths and decay cannot exist. As a curative agent simply, the application of heat is, however, unnecessary and injurious, causing a partial destruction of the flavour, and more or less fermentative change. Research has proved that between the limits of 32° and 60° F. (0° and 15° C.) vegetable substances retain their flavour and all other qualities, while giving up their moisture, no fermentative action being engendered. This has led to the adoption of the

Cold-blast System.—The fruit or vegetables are deprived of moisture by subjection to dried air at a low temperature. The air is compressed in a chamber containing chloride of calcium, or any other compound possessing strong dehydrating qualities. Chloride of calcium is in practice probably the best, as it so readily gives up the absorbed water on being heated. The compressed and dried air is then admitted into a chamber containing the substances to be treated. The expansion lowers its temperature somewhat, which should be maintained between 32° and 60° F. (0° and 15° C.). The substances are distributed throughout this chamber on perforated trays, so as to be fully exposed to the current of cold dry air passing through. All the moisture is thus removed, without the least detriment to the flavour, colour, and other virtues of the substance acted upon. The process has a great advantage over hot-drying, both in the cost entailed and the result achieved. Fruit and vegetables thus prepared, and packed with ordinary care, remain good for an indefinite period, and resume their natural shape and dimensions when placed in water.

Hot-air Process.—(1) A common method of conducting the operation is as follows: The fruit or vegetable is pared and cored, if necessary, and then finely shredded. The shreds are spread on galvanised-iron wire screens in the evaporator, a 3-storeyed chamber, through which passes a current of air heated to 240° F. (116° C.). The screens rest on endless chains, that move upwards at intervals of 3 to 5 minutes, when a fresh screen is put on below, and a finished one is taken off at the top. The evaporation is very rapid. The cores and peelings of apples, etc., are made into vinegar. (2) Another plan is by means of a vacuum-pan, heated to 120° to 170° F. (49° to 77° C.). The air is dried

by passage over chloride of calcium. The operation occupies 20 minutes.

Masson and Gannal's Process.—Vegetables are submitted for a few minutes to steam at 70 lb. a sq. in., then dried by air at 212° F. (100° C.), subjected to hydraulic pressure so as to form tablets, and, when required for use, are soaked in cold water for 5 hours.

Carsten's Process for Potatoes.—The potatoes are peeled and cut into discs, and are scalded by immersion in nearly boiling water. They are then dried hard in an oven. To preserve the white colour, they are treated with water acidulated with 1 per cent. of sulphuric acid. They are then washed in cold water and dried.

Sacc's Process.—Sacc's process for preserving vegetables is as follows: The vegetables are warmed to destroy their rigidity, and are then packed in barrels, and surrounded with ½ their weight of acetate of soda in powder, by which their moisture is absorbed. In summer the action is immediate; but in winter it may be necessary to put the barrels into a room heated to 68° F. (20° C.). After 24 hours, the vegetables are removed, and kept in a dry atmosphere. For use, they are soaked in cold water for 12 hours.

Cooking.—The preservation of vegetables by cooking them in sealed cases is dependent on the destruction of all organic germs by the heat of the boiling and the perfect exclusion of air. (*See* "Canning," page 445.)

Pickling.—Curing by means of acids, as acetic acid, vinegar, etc., is the process commonly known as "pickling." In the ordinary way, the vegetables are kept soaking for a long time in brine, and are then pickled in acetic acid. An improved method, by which months of time are saved, is to exhaust them under an air-pump, and then to force in spiced vinegar under a pressure of 45 lb. per sq. in.

Gum.—Hirschberg adds a few drops of sulphuric acid, whereby the lime contained in the gum is precipitated as sulphate; after standing, the mucilage is strained off, and exhibits no tendency to mouldiness even after standing for 18 months. ('Les Mondes.')

Hay.—Professor Wrightson, of the Royal Agricultural College, Cirencester, writes to the 'Times' as follows: Will you allow me a few lines' space to call attention at this seasonable time of the year to a process of preserving fodder for winter use little known, and, so far as I am aware, never practised in this country? It gives as its product what is known all over the Austrian Empire as "sour" hay, which, I may add, I have seen used extensively on many large estates. The process of making sour hay is not only exceedingly simple, but in the event of a wet season might be adopted in this humid climate with excellent effects, as neither drying wind nor sun are required. The green grass, green Indian corn, or other fodder is simply crammed down into graves or trenches, 4 ft. wide and 6 ft. to 8 ft. deep, until it forms a compact mass up to the surface, and the whole is then covered with 1 ft., or rather more, of earth, rounded over so to form a long mound. No salt is used, and the wetter the fodder goes the better. The preservation is complete, and when cut out with a hay spade in winter, the fodder is of a rich brown colour, and has a slightly sour, but on the whole agreeable flavour."

Honey.—Honey, according to Vogel, contains on an average 1 per cent. of formic acid. Observing that crude honey keeps better than that which has been clarified, Mylius has tried the addition of formic acid, and found that it prevents fermentation without impairing the flavour of the honey.

Indiarubber.—(1) In the opinion of Hempel, the hardening of vulcanized indiarubber is caused by the gradual evaporation of the solvent liquids contained in the indiarubber, and introduced during the process of vulcanisation. Guided by this notion,

he has made experiments for a number of years in order to find a method for preserving the indiarubber. He now finds that keeping in an atmosphere saturated with the vapours of the solvents answers the purpose. Indiarubber stoppers, tubing, etc., which still possess their elasticity, are to be kept in vessels containing a dish filled with common petroleum. Keeping in wooden boxes is objectionable, while keeping in airtight glass vessels alone is sufficient to preserve indiarubber for a long time. Exposure to light should be avoided as much as possible. Old hard indiarubber may be softened again by letting the vapour of carbon bisulphide act upon it. As soon as it has become soft, it must be removed from the carbon bisulphide atmosphere and kept in the above way. Hard stoppers are easily made fit for use again in this manner, but the elastic properties of tubing cannot well be restored. ('Ber. Chem. Ges.') (2) In order to prevent indiarubber materials from hardening and cracking, they are steeped in a bath of melted paraffin for a few seconds, or several minutes, in accordance with the size of the articles, and then dried in a room heated to about 212° F. (100° C.).

Preserving the Latex.—Careful experiments at the La Zacualpa botanical station and rubber laboratory have shown that by the addition of formalin, latex can be kept for at least twenty-seven months without changing its character. Salicylic acid in small quantities has also proved to be a good disinfectant of the latex.

Leather.—(1) Equal parts of mutton fat and linseed oil, mixed with $\frac{1}{16}$ their weight of Venice turpentine, and melted together in an earthen pipkin, will produce a "dubbin" which is very efficacious in preserving leather when exposed to wet or snow, etc. It should be applied when the leather is quite dry and warm. (2) Many other formulæ exist for dubbins, but all contain essentially the same ingredients. (3) A solution of 1 oz. solid paraffin in 1 pint light naphtha, to which 6 drops sweet-oil have been added, is put cold on the soles, until they will absorb no more. One dressing will do for the uppers. This process vastly increases the tensile strength of every stitch; and, while not removing the natural moisture of the leather, decidedly waterproofs the boot. A sole lasts 2 months longer when so treated. (4) There is nothing like castor-oil for preserving leather. Applied once a month, or once or twice a week in snowy weather, it not only keeps the leather soft, but makes it waterproof. Copal varnish is the best thing to apply to the soles; but the latter should be thoroughly dry, and if they have been worn, they should be previously roughed on the surface before applying the varnish. Linseed-oil is perhaps better than nothing, but it rots the leather; hence the objection to "dubbins" and other mix-ups of mutton-suet, linseed-oil, etc. The very best thing for waterproofing soles is Szerelmey's freestone liquid; 3 or 4 coats of this render the sole perfectly waterproof, and more durable. With regard to castor-oil, it may further be said that it does not prevent a polish being produced on the boots, and that leather so treated is avoided by rats, if even its proportion be only $\frac{1}{4}$ to $\frac{1}{3}$ tallow. (5) Long-continued observation shows that harness and other leather exposed to the action of ammonia continually given off in stables, become weak and rotten sooner than ordinary leather. Even when care is taken to protect them with grease, this takes place. The addition of a small quantity of glycerine to the oil or fat employed in greasing such kind of leather, has been recommended to keep it always pliable and soft.

Leeches.—The health and "biting" propensities of the *Sanguisuga* depend upon a number of circumstances, some of which are rather obscure, but it may be stated in general terms that the absence of decaying animal matter, and of too great an excess of lime-salts, are points which should be aimed at most particularly.

Sudden changes of temperature are also detrimental to leeches, which should be kept in rain-water of good quality frequently renewed, provided it is not too pure to afford them nutriment. They are peculiarly sensitive to electrical influences; many confined in the usual small receptacles will sicken and die, apparently "quite unaccountably," but really from the effects of that electro-inductive condition existing before a thunderstorm, and popularly known as "thunder in the air," If the usual leech-vase or barrel, say of glass or china, be put into direct conductive communication with the earth by means of a stout metallic chain dipping into the water and connected by its other extremity to, say, the gas- or water-pipes of a house, fewer leeches in summer will die than if this precaution is not taken. When kept in the usual rather small vessels, the water should be renewed every 8 or 10 days with fresh water of the same temperature* as that in the leech-vase iteelf. Dust must be excluded from the vessel by a covering of fine gauze, and the bottom should be occupied by a layer of clean fine gravel or coarse sand, to which has been added a few lumps of well-burnt oak or pine-wood charcoal. The whole of this bottom layer should be renewed within 6 to 8 or 10 weeks, according to the time of year. A little pure "crystallized" binoxide of manganese in the granular condition, and carefully freed from fine powder by sifting, is often of great assistance in keeping the water in a wholesome condition. Towards the same end also, a few growing plants of the *Vallineris spiralis* will powerfully contribute; but perhaps the most efficient factor in this direction, wherever it can be applied, is an arrangement for keeping the water slightly agitated, ands at the same time well aerated. This object can be readily attained by any simple "aspirator," whereby a slow current of water forces air down a small glass tube turning up under the surface of the fluid in the leech receptacle. In the end of this tube a small transverse section of dry cane should be cemented, so that the air emitted is distributed in minute bubbles. ('Burgoyne's Monthly,')

* As far as possible this should be kept within the limits 55° to 75° F. (13° to 24° C.).

Lemon-juice.—(1) A correspondent in 'Mém. de Méd. et de Pharm. Milit.' says after various experiments and the test of 8 months' exposure to the sun and heat of summer, he has come to the following conclusion: Heating the juice, or adding alcohol to the same, would appear to be superfluous, as it is only necessary to filter it and keep it in sealed bottles; however, since filtration proceeds so very slowly, the best way is, perhaps, to add 10 per cent. of alcohol to the fresh juice, and bottle.

(2) The 'Pharm. Jl.' observes that it may be preserved, without the addition of alcohol, by heating it to 150° F. (65½° C.), and then excluding it from the air by carefully closing the full bottles at this temperature. The operation should be carried out in winter.

Meat.—Dr. Richardson says that putrefactive changes in meat are due to the decomposition of the water contained in the tissues. The means which have been found to arrest this decomposition are—(*a*) a low temperature, (*see* REFRIGERATION); (*b*) a high state of desiccation; (*c*) the application of antiseptics; (*d*) the exclusion of air.

(*b*) *Desiccation.*—Animal matter, preserved by the absorption of its moisture, loses its flavour, and becomes tough and indigestible; the fat becomes rancid, and in damp weather the meat absorbs moisture, and turns mouldy and sour. These tendencies are corrected by adding absorbent substances with fat food—as sugar and spice, to form "pemmican," and farina, to produce "meat-biscuits." Altogether, the process seems ill-adapted for preserving meat in a fresh state, and two methods only need be mentioned.

(1) Tellier's.—The meat is placed in vessels whose air is repeatedly exhausted, and replaced by carbonic acid gas, which latter is finally absorbed

by a concentrated solution of potash. The meat loses 18 to 20 per cent. by weight, and is kept *in vacuo*.

(2) Sacc's.—This process has been described under Fruit. When applied to meat, the brine produced furnishes an extract of meat on evaporation, the acetate of soda crystallising out. This extract is added in the proportion of about 3 per cent. to the preserved meat. The latter, before use, requires to be steeped for 12 or 24 hours in water containing about ½ ounce sal-ammoniac to the pint.

(*c*) *Antiseptics.*—The use of chemical antiseptics has long been known, common salt being a very generally employed agent of this class. The difficulty seems to be to ensure the meat retaining its freshness, and to avoid its acquiring any unpleasant flavour. From among the very various processes devised the following are selected as being most noteworthy.

(1) Herzen's.—The quarter-carcases are soaked for 24 to 36 hours in a solution composed of 3 parts borax, 2 parts boracic acid, 3 saltpetre, and 1 salt, in 100 parts water; they are then packed with some of the same. Before use, they need 24 hours soaking in fresh water.

(2) Richardson's.—Dr. Richardson made some test experiments with meat treated with various antiseptics under a temperature varying from 45° F. (70° C.) to 110° F. (43° C.), for a period of 75 days. The results may be summarised thus:—Methylene: preservation, good; colour, imperfect. Methylal: faint taint of decomposition. Cyanogen: preservation excellent; colour, perfect; structure, firm. Sulphurous acid: some tainted, colour, dark. Sulphurous acid and lime-juice: some tainted; colour, indifferent. Sulphurous acid and glucose: some tainted; structure, dense. Nitrate of methyl: preservation, good; colour, yellowish; structure, firm. Formates: entirely fresh and excellent in colour.

(3) Medlock and Bailey's. — The meat is immersed in a solution composed of equal parts of water and bisulphite of lime, of 1·05 sp. gr. It acquires no unpleasant flavour. This is one of the most successful of the antiseptic processes.

(*d*) *Exclusion of Air.*—As the presence of oxygen seems to be essential to the existence of decomposition, many plans for the preservation of meat have been based upon the exclusion of air from it. By far the most important are the numerous modifications of cooking in air-tight cans, or glass bottles, called "canning," which have been conducted for years with great success. The heat of the cooking destroys any microscopic germs, if such be present, and at the same time expels all air from the receptacle and from the substance itself. The preservation is complete, but overcooking is unavoidable, and the meat is rendered soft, fibrous, and insipid. (*See* "Canning," page 445.)

(1) The raw meat is put into cans having a pin-hole, as before. The cans are placed for half their depth in a solution of chloride of calcium, boiling at 260° to 270° F. (127° to 131° C.). The heat is gradually raised from 180° F. (82° C.) to 230° F. (110° C.), and the steam is allowed to blow off for 4 hours, during which time the meat is being cooked. The holes are then closed by a drop of solder, the heat is raised to 260° to 270° F. (127° to 132° C.) for ½ hour, and the cans are withdrawn and cooled. Ritchie's deviation from this consists chiefly in desiccating the meat first in an oven at 400° to 420° F. (204° to 216° C.), and then packing it in cans, with the addition of meat jelly to create steam, before subjection to the chloride of calcium bath.

(2) Naylor's process.—The meat is cooked, and then packed in cases, and covered with stearine (tallow).

(3) Redwood's process.—The meat is immersed in melted paraffin at 240° F. (115° C.), to concentrate the juices, and expel the air. Thus condensed, the meat is covered with a coating of paraffin. Before use, it is

placed in boiling water, which removes the paraffin; it can only be used in its cold state, not bearing re-cooking.

Milk.—(1) Condensed Milk.—The compound known as "condensed milk" is an illustration of the application of the drying, or, desiccation theory, accomplished by evaporating the excess of moisture, adding sugar, and packing in hermetically sealed vessels. The milk, as received from the dairies, is placed in vessels having a capacity of 750 to 1000 gal., where it is maintained at a slightly raised temperature by means of steam-heat, and undergoes evaporation *in vacuo*. The duration of the process varies from 2 to 5½ hours. Refined sugar, in powder, is added in the proportion of about ¼ by weight of the total condensed product; and when the mass assumes the consistence of thick honey, it is put into tin boxes, and hermetically sealed. The proper conduct of the operation is by no means easy. There is much danger of a decomposition of the caseine in the presence of heat and sugar, especially if the milk has been in the slightest degree "turned"; also much of the fatty constituents will distil with the water, if the temperature is allowed to exceed 100° F. (38° C.). Attention has recently been called, in the *Analyst* and elsewhere, to the fact that these unfavourable conditions do frequently come into play, and that the loss of nitrogenous matter by decomposition, and the loss of equally important fat, partly volatilised, partly decomposed, so generally sustained by condensed milk, render it unfit to replace new milk in the nursery. Small quantities are prepared (almost solely for the American market) without the addition of sugar, in which case the evil is lessened; but the product does not keep so well.

(2) Mabrun's process.—This simple process was probably the foundation of the preceding. The milk is warmed at a moderate temperature, in a tin vessel furnished with a leaden tube for the expulsion of the air. The tube is then compressed, and the orifice is soldered up. After 6 months' keeping, the milk is as good as new. The process received a prize of 1500 fr. from the French Academy of Sciences.

(3) Morfit's process.—In 1 gal. milk at 130° to 140° F. (55° to 60° C.) is dissolved 1 lb. gelatine; the mixture is left to cool to a jelly, when it is cut into slices and dried. The compound is used to gelatinise more milk, and this is repeated till the gelatine is in the proportion of 1 lb. to 10 gal. of milk.

(4) Neumann points out that the electric state of milk, as effected by the bodies with which it come in contact, exerts an unquestionable influence over its keeping. Milk which has stood in a tin vessel, and is turned out into glass or pewter, will not keep sweet so long as if left in the tin. Milk will keep well in zinc, antimony, bismuth, copper, brass, or iron vessels; but iron is apt to impart a disagreeable taste; and copper, after a while, is found in notable proportion in the milk. Caution is therefore requisite with utensils of this metal. Block-tin vessels are best; but the milk should not be shifted from vessel to vessel, and the latter should be filled as full as possible.

(5) When milk contained in wire-corked bottles is heated to the boiling-point in a water-bath, the oxygen of the included small portion of air under the cork seems to be carbonated, and the milk will, it is said, keep fresh for a year or two.

(6) Glacialine.—According to Dr. Besana, this substance, which has met with so much favour in England and elsewhere as an antiseptic, especially for the preservation of milk, has the following composition:—Boracic acid, 18 parts; borax, 9; sugar, 9; glycerine, 6.

(7) A mixture of 2 dr. boracic acid with 3 dr. common salt, of which an addition of ½ dr. to 1 gal. of milk is said to increase its keeping qualities for 24 hours.

(8) According to Prof. Caldwell,

boracic acid is the best antiseptic for preserving milk or keeping it sound for an unusual length of time. When the temperature was 80° F. (27° C.), and the milk soured in 20 to 22 hours, 1 part boracic acid, added to 500 of milk, caused it to remain sweet for 50 hours. Again, he found that 1 part boracic acid, added to 1000 of milk by weight, kept it sweet for a space of 50 hours when the temperature was 72°F. (22° C.). When applied to milk warm from the cow, it kept it sweet and sound twice as long as milk not treated with it. No injury occurs to the milk in using 1 part boracic acid for 1000 of milk. Boracic acid, he stated, was not poisonous. He had partaken of milk thus preserved, and no harm resulted from the taking of such milk into the stomach.

(9) Portch states that salicylic acid cannot be considered a success for preserving milk or butter, as it conveys an unpleasant sweetish flavour, which increases till decomposition ensues.

(10) '*Buddeised*' *Milk*.—A new method of sterilising milk has just been perfected by Dr. Budde of Copenhagen. Dr. Budde—whose principle has been adopted by the Scottish Pure Milk Supply Company—holds that the principal point in purifying milk is to destroy the pathogenic germs by a process as mild as may be consistent with the retention of the good biolological qualities of fresh milk. His method utilises the germ-destroying power of nascent oxygen at a temperature of 120°, with the addition of at least as much peroxide of hydrogen as the milk can decompose. The peroxide, in small quantities, is a perfectly harmless substance, and there is in the milk an enzyme, named catalase, the characteristic quality of whose power is to decompose the hydrogen peroxide into water and oxygen. Dr. Budde claims that by treating the milk in this way all bacteria are destroyed and the milk made pure. The process consists in passing the milk through a heater, next through a centrifugal cleansing machine, and then into a vat provided with a mechanical stirrer and steam jacket. The milk is kept in the vat for three hours, with a temperature of 120°, and then it is filled through sterilised tubes into bottles that have been also thoroughly sterilised, and which have air-tight stoppers. The company by which the process has been adopted claim that they have solved the problem of supplying milk free from disease germs, and yet retaining the nutritive qualities in full and without giving the milk any unpleasant flavour.

Preservatives for Milk or other Foods, *for Size, and similar Compounds liable to Decomposition.*—There are three in general use, viz. boracic acid, salicylic acid, and formalin. In each case about ½ per cent. is used, mixed in water. Formic acid is considered to have excellent preservative qualities with acid solutions, such as fruit juices, etc. Carbolic acid paper is also used to a large extent for wrapping solid substances, such as meat. It has an excellent preservative effect. Take 10 parts of stearine and melt this with a gentle heat. When melted, stir in 4 parts carbolic acid. When this is done, add 10 parts melted paraffin wax, and set aside till it cools and sets. A portion is then melted and applied to the paper with a brush.

Raulin's and Pasteur's Fluids, *for preserving specimens.*—Both Pasteur's and Raulin's fluids are very difficult to keep. They are so extremely sensitive that the simple exposure of the fluids to air for 2 or 3 days (in a town) is sufficient to convert the whole into a ropy mass of mycelium. Then, again, starch solution is not easy to keep for any length of time. Chemists have, it is true, succeeded somewhat by the application of salt, calcium chloride, and other antiseptics; but these more or less interfere with the universal application of starch solution, and could not be used at all with either Pasteur's or Raulin's fluid. Two years ago, G. E. Davis devised a plan for keeping

such fluids as are above mentioned, and with the result that the remainder of a pint of Raulin's fluid made up in November, 1878, was as good 4 years after as when first mixed. The apparatus consists of an ordinary glass flask, fitted with an indiarubber stopper pierced with two holes, into one of which is tightly inserted a tube packed with clean cotton wool. Into the other hole the shorter limb of a glass siphon is inserted, the longer limb being closed with a spring clip upon a short length of rubber-tubing, in advance of which is a narrow glass jet. To put the apparatus in working order, nearly fill the flask with the fluid, and take out the cotton wool from the tube above; place over a lamp to boil, and, while boiling, open the clip, and stop up the open end of the wool tube, so that the pressure may drive some of the fluid out of the flask. Return this ejected fluid to the flask, and keep boiling for 5 minutes, allowing the steam to escape from the open wool tube. While steam is thus escaping, place a plug about ¼ in. in depth of cotton wool, and allow the steam to blow well through it. After 1 minute, plug the whole of the tube with cotton wool, and withdraw the flame. By simply opening the clip, a supply may now be withdrawn without the introduction of any atmospheric germs into the flask. ('Northern Microscopist').

Skins and Furs.—(1) About 40 years ago Waterton described his method of preparing and preserving the skins of animals and birds. The material used was simply mercury chloride (corrosive sublimate) dissolved in alcohol to saturation. This was applied with a camel-hair brush to the inside of the skin, the roots of the principal feathers, and all parts subject to decay. It was stated to give a remarkable firmness of attachment to feathers liable to come out, and so cleanly in use that the plumage of the most brilliant humming-bird was not soiled by its application. The corrosive sublimate must be very finely pounded. Highly rectified spirits of wine may be diluted with water equal in quantity. Thus, to 1 qt. bottle of alcohol add 1 qt. bottle of water. Into this put a tablespoonful of corrosive sublimate, and nothing more is required. Birds must be steeped in this solution before they are skinned; quadrupeds after they are skinned. Insects must be steeped after they have been dissected. So must serpents. (2) To preserve skins of any kind. First stretch them out on a board with tacks as soon as taken from the body; then cover them with wood-ashes; let them remain a fortnight, and renew the ashes every three days. (3) The following soap is recommended by Ward, of London: The skins must be well scraped and divested of all fat, and well rubbed with the soap: 1 lb. yellow soap, 1 oz. lime, 1 oz. camphor, 1 oz. arsenic, 1 oz. alum; mixed together. (4) Sublimed sulphur and nitrate of potash, of each, 2 dr.; black pepper, camphor, bichloride of mercury, burnt alum, and tobacco, of each, ½ oz.; reduce to a fine powder. (5) Bichloride of mercury, 1 oz.; hydrochloric acid, 3 dr.; methylated spirit of wine, add to, 2 oz. Use it as follows: Pour sufficient into a cup, and paint it freely on with a brush, especially about the cavities of the skull, the arms, wings, and thighs. A liberal supply of the powder (No. 4) afterwards to the same parts will ensure their keeping any length of time (that is, if you have any doubt about their keeping). If you would prefer it, you may use the powder alone.

Moleskins.—(a) To preserve and render the skins of moles soft and pliant, soak them for 3 or 4 days in water which has had oak sapling bark boiled in it for 2 or 3 hours. To 2 qt. water put a good double-handful or more of oak-bark, or, better still, oak-galls, and when this has got cold, put the mole-skins in, fresh flayed. They will dry soft and pliant, and perfectly cured. (b) Skin them neatly, turn them inside out, hang to dry, turn them when dry, and scrape them with

blunt knife. (*c*) Stretch the skin well on a board, with the fur downwards, and keep it in position by nailing it with tinned tacks round the edge. Then saturate it with spirits of camphor, and rub it in; after this, pour about a teaspoonful of rum on, and rub this in with common yellow soap, and leave it to dry. In 2 or 3 days it will be ready for taking off, and will be found to keep stretched, though limp through the application of the soap. They will keep thus for any length of time in a fairly dry place. (*d*) Nail the fresh skin tightly and smoothly against a door, keeping the skin side out. Next proceed with a broad-bladed blunt knife to scrape away all loose pieces of flesh and fat; then rub in much chalk, and be not sparing of labour; when the chalk begins to powder and fall off, take the skin down, fill it with finely-ground alum, wrap it closely together, and keep it so in a dry place for 2 or 3 days; at the end of that time unfold it, shake out the alum, and the work is over. (*e*) First clean and scrape the mole-skins, then rub them over with the following mixture: 4 lb. white curd soap, 1 lb. arsenic, 1 oz. camphor. Cut the soap into thin slices, and dissolve in 1 pint water. When melted, add the arsenic and camphor, stirring them well together; reboil until a thick paste is attained, and pour it into jars while hot. When cold, tie it up carefully with bladder, and it will keep for a considerable time—2 years.

Skin of Small Animals.—(*a*) Take the skin fresh, and immerse it in a strong solution of alum and salt. To ascertain when dressed enough, double the skin, flesh side outwards, twice, and press it firmly between your finger and thumb until the liquor is well pressed out. If, when opened, the crease on the skin looks white in the angle, it is dressed enough. Take it out, and immerse it just a minute in warm flour and water, and wash out the flour under a stream of water. When the skin is about half dry, lay it on a flat smooth piece of board, and scrape off the flesh with a blunt-edged knife, or rub it off with pumice. Your skin will then be as mellow as a Dent's kid glove. (*b*) The following is Dr. Lettsom's recipe for a mixture found to answer both for animals in cases, and skins in the open air. For birds it it equally good and effective: Corrosive sublimate, ½ lb.; saltpetre, prepared or burnt, ½ lb.; alum, burnt, ¼ lb.; flowers of sulphur, ½ lb.; camphor, ¼ lb.; black pepper, 1 lb.; tobacco, ground coarse, 1 lb. Keep in glass-stoppered bottle. Give 2 or 3 good rubbings with it.

Swan-skin.—6 oz. arsenic, 3 oz. corrosive sublimate, 2 oz. yellow soap, 1 oz. camphor, and ½ pint spirits of wine. Put all these ingredients in a saucepan, which place over a slow fire, stirring the mixture briskly till the several parts are dissolved and form one homogeneous mass. This may be poured into a wide-mouthed bottle, and allowed to stand till quite cold, when it will be ready for use. Of course these quantities may be increased or decreased, according to the size of the animal or bird to be operated on. If the soap and arsenic are left out, it will answer better, as they leave it greasy. To be put on with a sponge fastened on the end of a stick. Use very cautiously; mark *Poison.*

Small Birds.—(*a*) Small birds may be preserved for a considerable time by immersing them in brandy, or first runnings of the distillation of rum, but it may slightly discolour the plumage. After sufficient immersion, the feathers and limbs must be arranged as in life, and then slowly dried in an oven at moderate heat. (*b*) Make an incision from the breast-bone to the vent; with a small piece of wood work the skin from the flesh. When the leg is reached, cut through the knee-joint, and clear the shank as far as possible; then wind a bit of cotton-wool, on which some arsenical soap has been put, round the bone; do the same with the other leg. Now divide spine from root of tail, taking care not

to cut too near the tail feathers, or they will come out. Next skin the wings as far as possible and cut off. The skin will now be entirely clear of the body. The skin must be turned inside out, and the neck and skin gently pulled in opposite directions till the eyeballs are fully exposed. The whole of the back of the head may be cut off, and the eyes and brains taken out, and their places filled with cotton wool. The whole skin should be rubbed well with arsenical soap or plain arsenic, and the neck returned to its natural position, when, after filling the body with a little dry grass or wool, the job is done. It is very easy, and the skin of a bird is much tougher than one would suppose, though of course they vary, the night-jar being very thin, while humming-birds are fairly tough. All the apparatus required is a sharp knife and a pair of scissors, or, for large birds, a strong pair of nippers to divide the bones. Bird-skins are sent home in barrels very roughly packed.

Stone.—(1) As regards stone, other than such specially crystalline kinds as granite, marble, porphyry, hard limestone, etc.—none of which is liable to admit access of water from its external surface—we very much doubt the efficacy of any dressing; such, for instance, as what is called silicon varnish, or anything of the kind. The real and only effective means of preventing crumbling, blowing, or exfoliation is to make sure that the blocks are cut so as to be seated in the structure on their natural beds—that is to say, horizontally parallel to the direction of their natural fissures and *laminæ*, which, in the rock, keep the direction of the dip. The reason is this: water coming into contact with the external surface of a stone, of which the natural fissures are set perpendicularly or at a high angle, will inevitably be admitted into those fissures, and it will follow them down by gravitation, and promote the entry of more water after it until the fissures are full. If such conditions be promptly followed by keen frost, for example, the water so admitted is apt to be congealed and thus expanded, and then to prise the *laminæ* asunder, and blow out or exfoliate any scale of trifling thickness; and so long as the fissures are presented externally in such directions, no dressing whatever will effectually protect the stone. When, on the other hand, the stone is laid on its natural bed, and the fissures and *laminæ* are horizontal, all wet falls harmlessly down the face of the stone (outside). It is never admitted into the substance; and, what is more, most kinds of stone which are subject to such accidents, if preserved by proper placement from the inward access of water, have a tendency to become externally case-hardened in course of time, under outward exposure to the action of air and water, by a slow process of normal crystallisation, which ultimately endows them with real durability. ('Design and Work.')

(2) *To Preserve Sandstone from Decay.*—Brush it over with a solution made up of 4 gal. of water in which is melted 1 lb. of alum and ½ lb. of sugar of lead.

(3) *Transparent Waterproof Solution.*—½ cwt. common resin, 1 gal. oak varnish, 2 gal. coal-tar naphtha, 1 gal. boiled oil, ½ lb. slaked lime. Melt the resin in an iron pan, then take from the fire and allow to cool a little. Now add the naphtha, a little at the time, stirring to get well mixed. Next add the lime followed by the oil. Now allow to get cold, then add the varnish. Stirring is essential as each ingredient is added. The mixture may be used at once; but, if not, it should be kept airtight to prevent thickening. Should it thicken it may be thinned with more naphtha. Apply the first coat with a stiff brush, and well rub in to prevent subsequent suction. When dry (in 4 or 5 hours) give another coat with a varnish brush. If desired a stiff oil paint may be added with the naphtha (to the melted resin) to give colour.

Textile Fabrics.—*Bagging for Chemicals.*—A patent has been taken out by Grouchy for making bagging which resists chemical action. The bagging is plunged in the following solution at 142° F. (60° C.), and left for an hour:—

Sulphate of alumina	. .	2¼ lb.
Water	. . . . . .	5½ gal.
Borate of lime	. . .	2¼ lb.

The borate of lime is added after the sulphate of alumina has dissolved in the boiling water, and the whole decanted when settled. After taking out of this bath, the textiles are put in a second bath, composed of 2¼ lb. resinous soap, and 2¼ lb, Marseilles soap, dissolved in 5½ gal. water and carried to the boiling-point. At the end of 10 minutes the cloths are allowed to drip, dried, and then re-washed and dried. Bagging made in this way will, it is claimed, resist the action of any acids or chemicals put into them. ('New York Drug. Circ.')

Linen Stuffs and Yarns.—Sails, ropes, nets, etc., keep much longer when they have been treated with tannin. Hence Lebrun recommends the following process for preserving linen goods and yarn: 2¼ lb. good oak-tan is boiled for ½ hour in 4½ gal. pure running water. After filtering and pressing the residue, you get about 3¾ gal. tanning liquor. With this the stuffs or yarns are brewed in copper, earthen, or wooden vessels, but not in iron. The fluid must completely cover the stuffs or yarns, which should be left in it for 48 hours, and stirred round in it from time to time. They are then to be taken out, wrung, washed, wrung again, and, after being dried, they show a slight leather-like colour, and withstand all the effects of damp and the action of the weather much better than those not so treated. Unbleached goods may be treated in this way as well as bleached but they must be first steeped. Linen goods that are already partly decayed may be thus protected from further injury. Linen goods subjected to this process for 72 hours have been found unaffected by lying spread out for 10 years in a damp murky cellar, while untanned goods were almost completely destroyed.

Wood.—Two conditions of construction are necessary to preserve timber from decay—(1) continual access of a free current of air, by provision of proper ventilation; (2) the assured exclusion of wet from without. Neither damp nor dry-rot will readily attack timber which is so placed and protected. What most rapidly destroys timber is the alternation of wetting and drying; the next most frequent cause of decay is the generation of fungus by reason of total atmospheric stagnation. Another point of some importance is to avoid seating timber (such as wall-plates, joists, girders, breastsummers, &c.) in or abutting immediately upon masonry or brickwork which is being laid with Portland cement. Immediately next to all such faces or butt-ends of timber, the work should be laid with mortar made of 1 part (by weight) ground quicklime and 3 parts cleanly-sifted very dry and ground coal cinders; indeed it is best to have the lime and cinders ground together, so that they are perfectly blended: but it is indispensable to use this material at once, as it soon slakes from the action of moisture in the air. No dressing whatever will preserve timber as to which the foregoing precautions are neglected. It is, nevertheless, a good plan—in having a care on these points—to thoroughly dress internal timbers, such as girders, joists, wall-plates, rafters, window and door frames, etc., with a strong solution of carbolic acid before building them in. In sinking timber, as posts, in strong argillaceous soils, charring the heels to a height about 6 in. above-ground—and all spurs as well—is the only means of averting very prompt decay—unless it be by the costly precaution of seating the heels within pottery pipes of sufficient calibre, and filling in with smoking ground quicklime concrete mixed with crushed burnt stone.

The durability of wood depends on several circumstances, some being inherent to the wood itself, others owing to outward conditions. Woody fibre, by itself, is very little affected by air or water, but several other principles may be present in wood which, by entering into decomposition, induce a similar state in the woody fibre; such are albumen, etc., which exist in the sap. Resinous bodies, by preventing the absorption of water, and by being distasteful to most insects, act as preservatives; hence, most naturally, resinous woods are durable. The heart-wood of trees is less liable to attacks from insects than the outer or splint-wood. Dry wood is also but little liable to such attacks. Young sappy wood, on the other hand, is specially prone to attacks from insects. Trees grown in cold climates and in poor soils produce wood which is, as a rule, more durable than that obtained from similar trees grown in a warmer, richer, and moister soil. Wood felled in winter is more durable than that felled in the spring or summer, probably owing to the sap not being so abundant at the former epoch. Wood placed in warm and moist situations, especially if light and air be excluded, is more liable to decay than when placed in dry, cool, and airy positions. Moisture and close atmosphere favour the growth of peculiar fungi on the wood, which eventually favour the decomposition of the fibres and the disintegration of the mass. These fungi are generally the *Thelephora domestica*, the *Boletus destructor*, and the *Cerulius vastator*. A remedy for the ravages effected by these fungoid growths is found in the repeated application of acetate of iron made from wood vinegar. As the sap is such an active agent in the rapid decay of wood, any means by which its removal can be effected, even if only partially, will conduce much to the preservation of the wood. Soaking in cold water, boiling in water, steaming in close vessels, have all been tried, and found effective under certain circumstances. Drying and charring the external portions have also been found efficacious. To this end the wood is immersed or painted over with tar, creosote, or similar bodies, after being well kiln-dried; the tar is then lighted and allowed to char the wood superficially. When extinguished, it may again be tarred.

(1) By causing the root end of a freshly-felled tree to stand in a solution of sulphate of iron, bichloride of mercury, sulphate of copper, etc., these bodies are sucked up into the wood, and replace the sap. This method seems to be the one which gives the most promising results, and wood treated in this manner with sulphate of iron becomes extremely durable. ('Eng. Mech.')

(2) Inquiries into the causes of decay of timber prepared with copper salts have been made by H. Rottier, of the University of Ghent. The disappearance of the copper-sulphate may be accounted for by the presence of (1) iron, (2) certain solutions, (3) carbonic acid. The action of iron had been recognised for some time. Rottier mentions an experiment made with chips of wood impregnated with solutions of copper-sulphate containing sulphate of iron in various proportions, and buried in the ground. The results showed—(1) that the ferrous sulphate had a certain antiseptic action, but much weaker than that of the copper; (2) that the duration of woods prepared with sulphate of copper solutions containing ferrous sulphates in varying proportions was nearly equal, except where the ferrous sulphate was present in very large proportion; (3) that for preserving wood, chemically pure copper-sulphate offered no advantages over common commercial sulphate. The last conclusion is opposed to the view taken by Boucherie and other specialists. Rottier cites, in support of his opinions, the observation of Layen on an ancient wheel found in the copper mines of São Domingo, in Portugal. This wheel was in a perfect

state of preservation, although it had been for 1400 years in water containing not only the sulphates of copper and iron, but notable quantities of the subsulphates of these metals.

Certain salts have an injurious action on wood impregnated with copper-sulphate. If chips of wood so prepared are placed in a solution of chloride of lime, carbonate of soda, or carbonate of potash, the solutions will be found after a while to contain considerable quantities of copper-sulphate abstracted from the wood. This shows that timber so prepared is unsuited for marine constructions. It explains, too, why such wood is liable to decay when employed in tunnels, or in certain soils, as those containing much lime. The salts (as bicarbonate of lime, etc.) present in the water carry off the copper from the wood.

In certain soils carbonic acid will also abstract the copper. This may be shown by placing chips impregnated with copper sulphate in aerated water.

Rottier has endeavoured to prolong the duration of the wood by increasing the proportion of metal fixed in the ligneous fibre. Here it is necessary to have recourse to special modes of procedure, as when the wood is simply laid in a solution of the sulphate, the proportion of the latter, which becomes fixed, is pretty nearly constant and very small. He has found also—(1) That acetate of copper enables us to double the quantity of copper fixed. (2) Heating the wood also augments the quantity of copper fixed. (3) Certain organic substances have the same effect, acting on the ligneous fibre much in the same way as do mordants in dyeing processes. The effects of indigo and catechu in this respect are very remarkable. (4) The use of cuprammonium salts permits a much larger quantity of copper to be introduced into the wood. Experiments with shavings impregnated in various ways, and buried in a cesspool, proved that the durability was greater in proportion as the amount of copper fixed was larger. Acetate of copper and indigo are too uncertain for general use. The effects of heat are not so reliable. Catechu can only be employed to a limited extent. Cuprammonium salts, on the other hand, admit of general application, and the trifling increase in prime cost would be more than compensated by the longer duration of the wood. ('Revue Indust.')

(3) To cure incipient dry rot.—(*a*) If very much infected, remove the timber, and replace with new. (*b*) A pure solution of corrosive sublimate in water, in the proportion of 1 oz. to 1 gal., used hot, is considered a very effectual wash. (*c*) A solution of sulphate of copper, ½ lb. per gal. of water, laid on hot. (*d*) A strong solution of sulphate of iron; this is not so good as sulphate of copper. (*e*) A strong solution of sulphates of iron and copper in equal parts, ½ lb. of the sulphates to 1½ gal. water. (*f*) Paraffin oil, the commonest and cheapest naphtha and oil, or a little resinous matter dissolved and mixed with oil, will stay the wet rot. (*g*) Remove the parts affected, and wash with dilute sulphuric acid the remaining woodwork. (*h*) Dissolve 1 lb. sulphate of copper in 1 gal. boiling water, then add 1½ lb. sulphuric acid in 6 gal. of water and apply hot. (*i*) The best preservative against dry rot, according to the American 'Journal of Pharmacy,' is the following: 1 part oil of cassia, 1 wood tar, and 1 train-oil; apply 3 coats on the reverse sides, and on the ends of planks, floors, etc. In all probability oil of cassia plays the chief rôle as preservative.

(4) *Bethell's*.—This appears to be one of the most successful means yet adopted for preserving wood from dry rot, and even wet rot, or the attacks of the white ant and *Teredo navalis*. It consists in impregnating the substance of the wood with the oil of tar called *creosote*, from which the ammonia has been expelled, the effect being to coagulate the albumen, and thereby prevent its decomposition, also to fill the pores of the wood with

a bituminous substance that excludes both air and moisture, and which is noxious to the lower forms of animal and vegetable life. In adopting this process, all moisture should be dried out of the pores of the timber. Fir or pine, while warm from the drying-house, may be immersed at once in an open tank containing hot creosote oil, when it will absorb about 8 or 9 lb. per cub. ft. For hard woods, and soft woods which are required to absorb more than 8 or 9 lb. of creosote per cub. ft., the timber should be placed in an iron cylinder with closed ends, and the creosote, which should be heated to a temperature of about 120° F. (49° C.), forced in with a pressure of 170 lb. to the sq. in. The heat must be kept up until the process is complete, to prevent the creosote from crystallising in the pores of the wood. By this means the softer woods will easily absorb 10 to 12 lb. of the oil per cub. ft. The most effective method, however, is to exhaust the air from the cylinder after the timber is inserted, then to allow the oil to flow in, and when the cylinder is full to use a force-pump, with a pressure of 150 to 200 lb. per sq. in., until the wood has absorbed the requisite quantity of oil, as indicated by a gauge which should be fitted to the reservoir tank. The oil is usually heated by coils of pipes placed in the reservoir, through which a current of steam is passed. The quantity of creosote oil recommended to be forced into the wood is, for railway sleepers, telegraph poles, and other purposes on land, 8 to 10 lb. per cub. ft.; for piles, jetties, and other marine works, 12 lb. Into oak and other hard woods it is difficult to force, even with the greatest pressure, more than 2 or 3 lb. of oil.

(5) The value of creosote as a wood preserver is generally recognised, but the direct injection requires great quantities of heavy oil, and a desiccation of the injected pores. The high boiling-point of creosote does not permit its employment in vapour. Blythe formed the idea of saturating a jet of steam with creosote in minute division, forming, so to speak, a gaseous emulsion. The apparatus comprises a high-pressure steam-boiler; another boiler containing creosote, in which the steam is saturated; a vat, filled with creosote, to be pumped into the boiler; sheet-iron cylinders, for the pieces which are to be injected; and a system of tubing connecting the several parts. In this way Blythe completely fills the heart of oak, pine, or red beech; he uses 4 to 6 lb. of creosote for a cross-tie, and 4 lb. of brown phenic acid per cub. yd. of saturated wood or cross-ties. The apparatus can prepare 500 ties per day. The wood comes out softened, so that it can readily be bent or shaped, but it rapidly hardens. At first it shrinks, but, after a few weeks it becomes seasoned, and resists the influences of moisture. Finally, the fibres are greatly strengthened.

(6) *Krug* employs the following simple preparation for preserving wood used in mines by a combination of creosote and soda: An iron basin, ¼ in. thick, about 6½ ft. deep, and 4 ft. in diameter, is sunk in the ground rather more than half its depth. By the side, and with its rim below the bottom of the first basin, is a second, not quite half its size. A third basin, about mid-way between the other two in size, stands with its lower edge rather higher than the upper rim of the first basin. This first one is provided with a cover, half of which is screwed on, the other half may be opened or shut close. Above the bottom it has a sieve-bottom of wire-gauze, and at the bottom a discharge-cock. Moreover, a pipe goes to the bottom, through which steam can be directly conveyed. From beneath the upper edge a pipe passes over the edge into the second basin. In the second basin is a hand forcing-pump, for pumping the impregnating fluid into the third basin, which is furnished with a discharge-cock. The operation is as follows: The pieces of wood to be impregnated are cut to the suitable lengths required for door-posts, lintels, piles, etc., and

placed perpendicularly, as closely as possible together in the first basin, the cover of which is then closed. It is not necessary that the cover should be air-tight. Meanwhile, the third basin has been filled with creosote soda-lye, either directly or out of the second basin, by means of the hand-pump. The lye is then admitted into the first basin till it is about ⅔ full, and then steam is conveyed directly through the pipe mentioned before to the lye. The fluid gradually begins to boil, while it is increased by the condensation water of the steam, which pours in, and at last begins to flow away through the pipe which passes over the edge of the second basin. The steam is then turned off, and the wood may be left to boil for some time in the lye. When at last the lye has been discharged, and the wood been acted upon by direct steam, the cover of the basin is opened, and the impregnated wood removed. Although wood treated in this way is penetrated with the impregnating fluid only to the depth of ½ to ⅔ in. it has been found perfectly unimpaired after 5 years in districts where wood not so treated rots and becomes unfit for use after 9 or 12 months. Above ground, and in places where there is no danger of fire, it is sufficient to pour creosote-oil over the wood. In a few days the wood will be sufficiently penetrated to withstand the action of the weather. ('Stummer's Ingénieur').

(7) *Boucherie's.*—This consists in impregnating the timber with a solution of 1 oz. copper sulphate to 100 of water, as follows: A water-tight cap is placed on one end of the log to be saturated, and the solution is introduced within it by a flexible tube. The pressure required, not being more than 15 to 20 lb. on the sq. in., may be obtained by simply raising the tank to a height of 30 or 40 ft. from the ground. On this pressure being applied, the sap runs in a stream from the opposite end of the log. A piece of prussiate of potash rubbed on the end of the log will show if the solution has penetrated the entire length or not, for on coming in contact with the sulphate of copper, it leaves a deep brown mark on the wood. Margary in his process also used sulphate of copper in the proportion of 1 lb. of the salt to 8 gal. water, in which the wood was merely steeped until thoroughly saturated, which was supposed to take 2 days for every inch in the thickness of the wood. Boucherie also used the impure pyrolignite of iron, which was found not only to preserve the wood from decay, but also to harden it.

(8) *Burnettizing.*—A solution of 1 lb. chloride of zinc to 4 gal. water for timber, and 1 lb. to 5 gal. for canvas, cordage, etc., in a wooden tank. These were the proportions originally specified; 1 lb. of the salt to 9 or 10 gal. water are now more frequently used. Timber requires to be immersed for about 2 days for each inch in thickness, and afterwards taken out and left to dry for about 14 to 90 days. Canvas, ropes, etc., require to be immersed in the solution for about 48 hours, then taken out and dried. The process on wood may be more expeditiously performed by forcing the solution into the pores with a pressure of 150 lb. to the sq. in. The advantage of this process is that it renders the material to which it is applied incombustible.

(9) *Robbin's Process.*—The apparatus used consists of a retort or still, in which resin, coal tar, or other oleaginous substances, together with water, are placed in order to subject them to the action of heat. Fire being applied beneath the retort containing the coal tar, etc., oleaginous vapour commences to rise, and pass out through a connecting pipe into a large iron tank or chamber containing the timber, etc., to be operated upon. The heat acts at once on the wood, causing the sap to flow from every pore, which, rising in the form of steam, condenses on the body of the chamber, and discharges through an escape pipe in the lower part. In this process a temperature

of 212° to 250° F. is sufficient to remove the surface moisture from the wood; but after this, the temperature should be raised to 300° or more, in order to completely saturate and permeate the body of the wood with the antiseptic vapours and heavier products of the distillation. The hot vapour coagulates the albumen of the wood, and opens the pores, so that a large portion of the oily product or creosote is admitted; the contraction resulting from the cooling process hermetically seals them, and decay seems to be almost impossible. There is a manhole in the retort, used to change or clean out the contents; and the wood chamber is furnished with doors made perfectly tight. The whole operation is completed in less than one hour.

(10) *Kyanising.*—The timber is immersed in a saturated solution of corrosive sublimate (bichloride of mercury) in a wooden tank, put together so that no metal of any kind can come in contact with the solution. 1 lb. corrosive sublimate to 10 gal. water is used when a maximum strength is required, and 1 lb. to 15 gal. when a minimum, according to the porosity of the timber; with the latter proportion, 1½ lb. will be sufficient for a load of timber of 50 cub. ft. Corrosive sublimate dissolves best in tepid water. The time required to saturate the timber depends on its thickness; 24 hours are usually allowed for each inch in thickness for boards and small timber; large timber requires 2 to 3 weeks.

(11) *Payne's.*—Impregnating the wood, while in a vacuum, with a strong solution of sulphate of iron, and afterwards forcing into the timber a solution of sulphate of lime, or any of the alkaline carbonates, such as carbonate of soda, by which means the oxide of iron becomes insoluble. The wood is also rendered incombustible by this process.

(12) *To Preserve Woodworks that are exposed to Damp.*—(*a*) For those of an extensive nature, such as bridges, etc. The Hollanders use for the preservation of their sluices and floodgates, drawbridges and other huge beams of timber exposed to the sun and constant changes of the atmosphere, a certain mixture of pitch and tar, upon which they strew small pieces of shell broken finely—almost to a powder—and mixed with sea-sand, and the scales of iron, small and sifted, which incrusts and preserves it effectually. (*b*) A paint composed of subsulphate of iron (the refuse of the copperas pans), ground up with any common oil and thinned with coal-tar oil, having a little pitch dissolved in it, is flexible, and impervious to moisture. (*c*) Linseed-oil and tar, in equal parts, well boiled together, and used while boiling, rubbed plentifully over the work while hot, after being scorched all over by wood burnt under it, strikes ¼ in. or more into the wood, closes the pores, and makes it hard and durable either under or out of water. (*d*) For fences and similar works, a coating of coal-tar, sanded over; or boil together 1 gal. coal-tar and 2¼ lb. white copperas, and lay it on hot.

(13) *To Prevent Worms in Timber.* (*a*) Anointing with an oil produced by the immersion of sulphur in aquafortis (nitric acid) distilled to dryness, and exposed to dissolve in the air. (*b*) Soaking in an infusion of quassia renders the wood bitter. (*c*) Creosoting timber, if the smell is not objectionable. (*d*) Anointing the timber with oil of spike, juniper, or turpentine, is efficacious in some degree. (*e*) For small articles, cover freely with copal varnish in linseed-oil.

(14) *To Prevent Worms in Marine Building.*—(*a*) A mixture of lime, sulphur, and colocynth with pitch. (*b*) Saturating the pores with coal-tar, either alone or after a solution of corrosive sublimate has been soaked and dried into the wood. (*c*) Sheathing with thin copper over tarred felt is esteemed the best protection for the bottoms of ships for all marine animals; the joints should be stopped with tarred oakum. (*d*) Studding the parts under water with short broad-headed nails.

(15) *To Destroy Worms in Carvings.* (*a*) Fumigate the wood with benzine. (*b*) Saturate the wood with a strong solution of corrosive sublimate; if used for carvings, the colour should be restored by ammonia, and then by a weak solution of hydrochloric acid; the holes may be stopped up with gum and gelatine, and a varnish of resin dissolved in spirits of wine should afterwards be applied to the surface. (*c*) Whale-oil and poisonous ointments have been found of service. The wood should be carefully brushed before being operated upon.

(16) *To destroy ants and insects in wood.*—(*a*) Corrosive sublimate is an effectual poison to them. (*b*) Oils, especially essential oils, are good preventives. (*c*) Cajeput-oil has been proved effectual for destroying the red ant. (*d*) Payne's, Bethell's and Burnett's processes are said to be proof against the white ant of India. (*e*) Dust the parts with pounded quicklime, and then water them with ammoniacal liquor of gas-works, when the ammonia will be instantly disengaged by the quick-lime, and this is destructive to insect life. (*f*) For the black ant, use powdered borax; or smear the parts frequented by them with petroleum oil; or syringe their nests with fluoric acid or spirits of tar, to be done with a leaden syringe; or pour down the holes boiling water to destroy their nests, and then stop up the holes with cement. Ants dislike arsenic, camphor, and creosote. (Britton.)

(17) Nicholson, noting that railway sleepers lying on ground which had formerly been the bed of a salt lake, in Nebraska, retained their power to resist decay for an unusually long period, and showed an excess of alkaline salts in their ash, suggests that here is a cheap and effective preservative.

(18) Lostal, a French railway contractor, recommends the use of quicklime for preserving timber. He puts the planks in tanks and covers them with quicklime, which is gradually slaked with water. Timber, such as is used in mines, takes about a week to become thoroughly impregnated. The wood acquires a remarkable hardness and toughness, and, it is said, will never rot. Beechwood has been prepared in this way for hammers and other tools in several ironworks, and is reported to have been as hard as oak, without losing its peculiar elasticity.

(19) Wood will be effectually preserved from the action of the air if it is covered by a paint-brush with a solution of persulphate of iron, marking 2° to 2½° B. The blue tint which is developed by drying changes to brown when a coat of linseed-oil is laid on. ('Revue Indust.')

(20) For the purpose of preserving timber for mines, Koug packs the timber, cut in proper lengths, in a vertical position in an iron reservoir, provided with a tight-fitting cover. The vessel is then filled to about ⅔ of its capacity with a solution of the carbolate of soda. Into this he leads live steam, which speedily brings the liquid to the boiling-point. The access of the steam is continued until, by its gradual condensation, it has filled the vessel to its full capacity. The wood is then allowed to remain in the hot liquid some hours; this is drawn off, and the wood washed off with a dry steam jet.

(21) Hock dissolves paraffin in ligroin, so-called petroleum ether, kerosene, or other convenient substances, and immerses the wood to be preserved in the solution, care being taken that the wood is as dry as possible. After impregnation, the saturated wood is heated in a large retort provided with a condensing arrangement, whereby the volatile solvent is expelled and condensed for use over again, whilst the paraffin is left in the pores of the timber. Crude paraffin (containing much liquid hydrocarbons) may be employed.

(22) Jacques first impregnates the timber thoroughly with a simple solution of soap mixed with an acid—pre-

ferably phenic acid. This causes the formation in a few days, within the wood, of a fatty acid; which is insoluble in water, and impregnates the remotest fibres. The reaction of the acid on the soap does not take place until a portion of the water has evaporated. It is claimed that more perfect impregnation can be had in this way than with creosote, and there is no danger of the washing out of the preservative from the exposed surfaces, as when sulphate of copper is used. The Government commission on technical railroad operation in France is said to favour this process.

(23) Card impregnates the wood with a solution of zinc chloride, or other antiseptic soluble mineral salt, then dries the outer layers of the wood by heated air currents, and finally saturates with hot creosote-oil. The creosote-oil is to prevent the soluble antiseptic from being washed out.

(24) Richard uses common salt, in a chemically pure crystallised form, as the most efficacious preservative of timber. In combination with alum, absolute incombustibility, it is said, can be ensured by its use. ('Revue Indust.')

(25) The well-known methods of preserving posts and wood which are partly embedded in the earth, by charring and coating with tar, are only effective when both are applied. Should the poles only be charred, without the subsequent treatment with tar, the charcoal formation on the surface would act as an absorber of the moisture, and, if anything, only hasten the decay. By applying a coating of tar without previously charring, the tar would only form a casing about the wood, nor would it penetrate to the depth which the absorbing properties of the charcoaled surface would ensure. Wood that is exposed to the action of water, or let into the ground should first be charred, and then before it has entirely cooled, be treated with tar till the wood is thoroughly impregnated. The acetic acid and oils contained in the tar are evaporated by the heat, and only the resin is left behind, which penetrates the pores of the wood and forms an airtight and waterproof envelope. It is important to impregnate the poles a little above the line of exposure, for here it is that the action of decay affects the wood first, and where the break always occurs when removed from the earth or strained in testing. ('Ind. Blätt.')

(26) *Leech* takes 1 lb. arsenious acid and dissolves it in 4 gal. water; to this he adds 1 lb. carbonate of soda, stirring the mixture till it is thoroughly dissolved. In a separate vessel he makes a solution of 16 lb. sulphate of copper in 16 gal. water, mixes the solutions together, and places them in a wooden or a lead-lined vat. The timber is placed in this bath, and the solution heated by means of steam to the boiling-point. A few hours' soaking is said to be sufficient, but when heat is not applied the wood must remain for at least 2 or 3 days. These solutions are applicable to wood that is already in permanent position, as telegraph-poles, fences, and gates. In these and similar cases one solution should be painted on and allowed to dry before the other is applied. When possible, they should be laid on hot.

(27) *Mewburn's process*, so far as oak is concerned, consists simply in boiling the wood in a solution of gallo-tannic acid, the proportions of the respective ingredients being apparently immaterial. The result is the formation of an insoluble substance in the pores of the wood. One solution only is necessary for oak, on account of the tannin naturally present in that wood, the endurance of which in moist situations is proverbial. A consideration of this fact led Hatzfeld to try the effect of impregnating timber with tannin, and afterwards with acetate of iron, a process which is both cheap and useful, and which is at present being tested by a telegraph company in France.

(28) Posts and pier-piles can be rendered nearly indestructible by boring one or more holes, larger or smaller, in the centre of the butt, the whole

length if desirable; then fill with boiling coal-tar and close the aperture with a long taper wedge, well driven home, which will give pressure to force the antiseptic into the inner heart pores of the mould. Were posts thus preserved, and the exterior surface dressed with resin-varnish, they would last for centuries. Wood exposed to air should not be dressed with coal-tar, but Stockholm tar or resinous varnish; the former will rot the fibres when exposed to sun and air. Mark the posts at 6 or 8 in. above the depth they are to be placed in the earth, and bore the hole up to the mark. Then fill in with boiling coal-tar, plug up the hole, and the base of the post will outlast the upper part. The writer has also had occasion to stand posts under floor joists, as a support, when, by making a clay puddled hole, and pouring into it a gallon of boiling coal-tar as a bed for the posts to stand in, they would never decay. ('Eng. Mech.')

(29) Paulet compares the relative advantages of copper sulphate and creosote. As regards the former preservative, this salt is poisonous to the vegetable and animal parasites which appear at the beginning of all organic decomposition. The quantity of salts of copper should be excessive when the wood is intended to be immersed in water or buried in a moist soil, because the water dissolves this salt slowly; and since sea-water enters into combination with it still more rapidly, it should be excluded from use for wood used in the sea. There is, in wood impregnated with the salts of copper, a portion of the sulphate closely united with the ligneous tissue, and another portion in excess remaining free. The latter portion dissolves first, and, carried off by the exterior fluids, only retards the loss of the metallic salt combined with the wood; but this combination itself, although more stable, does not escape removal, being accelerated or retarded according to the rapidity and ease with which the dissolving liquid is renewed. On the contrary, the quantity of metallic salts should be diminished in wood intended for constructions in the open air, in order to prevent the mechanical effect of intra-vascular crystallisations. As regards creosote-oil, it is beyond doubt that the petroleum products, containing phenic acid, are preferable to the metallic salts for wood exposed to sea-water, because naphthalene, and especially phenic acid, exert an antiseptic action, coagulate the albumen, and thus obstruct the circulation of the sap, or blood of parasites. The volatility and the solubility of these preservative agents would render their antiseptic action temporary only, if the more fixed and thicker oils which accompany them did not enclose and retain the preceding substances, at the same time obstructing all the pores of the wood and rendering difficult the access of dissolving liquids and destructive gases. On the other hand, grave objections have been raised, from a practical point of view, either because of the restricted production of these oils, which is not sufficient for a general use of them, or because the wood thus impregnated offers great danger from fire, this wood, once on fire, being unextinguishable; on the other hand, sulphate of copper, like all metallic salts, renders wood uninflammable. ('Pract. Mag.')

(30) *Zinc Creosote Process.*—An interesting account of this process for preserving wood was given in a paper read before the Western Society of Engineers, Chicago. Dead oil and chloride of zinc being the active agents employed. It is specially suitable for railway sleepers, bridge timbers, and for situations where wood is exposed to any great degree of moisture. The timber is first of all steamed in a vacuum; the oil is then injected into the cylinder in which the wood is placed; after which the chloride of zinc is applied by pressure. It is said that the oil penetrates the pores of the wood to a certain extent, and the chloride of zinc goes to those portions unreached by the oil.

(31) *Garden Labels.*—The following

method of preserving garden labels is recommended in a German paper: Thoroughly soak them in a strong solution of copperas (sulphate of iron), then, after being dried, lay them in lime-water. This causes the formation in the wood of sulphate of lime, a very insoluble salt. The rapid destruction of labels by exposure to the weather is thus, it is said, prevented. Bast, mats, twine, and other substances used in tying up, or covering trees and plants, when treated in the same manner, are similarly preserved. At a recent meeting of a horticultural society in Berlin, wooden labels treated thus were exhibited, and although they had been continually exposed for 2 years, they were apparently in no way affected.

Yeast.—(1) The thick portion of the yeast is filled into a champagne bottle, and on top of it is poured about ½ in. of olive-oil. The bottle is then closed by tying a bladder over its top, and in order to protect it from explosion a pin is put through the bladder. So the yeast will keep well for a long time if stored in a cold place. (2) Yeast, if mixed with about ⅛ pure glycerine, also keeps well for some time if in a cool place. ('Chem. Rev.') (3) The raw yeast is carefully washed with cold water, afterwards the greater part of the water is removed by pressure; a further proportion is got rid of by means of a centrifugal apparatus. But as the yeast cannot be got perfectly dry in this way, it is afterwards placed for that purpose in an apparatus in which a vacuum, or rarefaction of the air nearly approaching a vacuum, can be obtained. In this chamber, the moisture, still combined with the yeast, evaporates at a very low degree of heat, and the vapour formed is immediately absorbed by hygroscopic substances introduced for the purpose—as for example, chloride of lime. The yeast is finally exposed to a current of air in its ordinary state or dried or of carbonic acid gas, according to the prevailing temperature and other circumstances. Through these manipulations a perfectly dry powder is finally obtained, which, being hermetically sealed in glass or tin cases, will keep perfectly well for several months. When required to be used, the powder is mixed with water to the consistence of a thin paste, which acts in the same way as fresh yeast. (Jeversen and Boldt.)

PRINTERS' ROLLERS.

THESE consist of a mixture of glue and treacle, and it is usually considered that the more treacle that can be used, consistent with its producing a roller of sufficient stiffness, the better; and, water having to be used to dissolve the glue, the less water in the composition the better.

(a) Summer use, 1½ lb. best glue and 4 lb. treacle; winter use, 1 lb. best glue and 4 lb. treacle. Soak the glue about 1½ hour if thick, if thin 1 hour. Take it out of the water, lay it on a board until next day, then melt down in proper melting pot, or put it in a saucepan and place it in another containing water. Do not let the water run over into the glue; one great secret in roller casting is to have as little water in the glue as possible. Add treacle as above, let boil once, then keep it just under boiling point until cooked, which takes about 2 hours, more or less; pour out into moulds, well cleaned and greased; if the composition is left too long on the fire it will get thick and spoil. The above is sufficient for an 18-in. roller; other sizes in proportion.

(b) To 8 lb. transparent glue add as much rain or river water as will just cover it, and occasionally stir it during 7 or 8 hours. After standing for 24 hours, and all the water is absorbed, submit it to the action of heat in a water bath, that is, surrounded by water, as glue is generally heated, and the glue will soon be dissolved. Remove it from the fire as soon as froth is seen to rise, and mix with it 7 lb. molasses, which has been previously made tolerably hot; stir the composition well together in the water bath over the fire, but without suffering it to boil. After being thus exposed to the heat for half an hour, and frequently well stirred, it should be withdrawn from over the fire and allowed to cool for a short time, previous to pouring it into a cylindrical mould made of tin, tinned sheet iron, or copper, having a wooden cylinder previously supported in its centre by means of its end pivots or gudgeons. After remaining in the mould at least 8–10 hours in winter, and a longer time in summer, the roller is to be taken out of the mould by means of a cord fastened to one of the gudgeons, and passed over a strong pulley fixed to the ceiling; but care must always be taken that the cylinder is drawn out slowly from the mould. Old rollers are recast in the same manner, first taking care to wash them with a strong alkaline lye, and adding a small quantity of water and molasses. The best mode, however, of making use of the old composition, is by mixing it with some new, made of 2 lb. glue and 4 lb. molasses.

(c) The following are a few recipes from various authorities: (1) 1 lb. of good glue is carefully softened as already described, then the water is poured off. Melt the glue in a water bath, and add 2 lb. treacle or American honey. (2) 4 lb. good glue soaked in plenty of water for half an hour, pour off water, and let the glue stand until softened through. Melt with gentle heat, then add ½ gal. of sugarhouse molasses. Boil for one hour. Do not boil too much or the molasses may partly crystallise and so lose its power of suction. This is for summer. In winter, halve the quantity of glue. (3) Treacle 6 lb., glue 4 lb., Paris white ½ lb. (4) Glue 5 lb., sugar 5 lb., glycerine 6 lb. (5) Before casting a roller see the mould is quite clean and then oil every part with a swab, but not excessively. (6) When rollers are being put away they should not be washed; the ink on them is a protect tion from the air. Washing should be done about half an hour before use. (7) When re-casting add a little treacle to the composition.

PULLEY BLOCKS AND TACKLE.

(*See also* TYING AND SPLICING.)

IF a single sheaved pulley-block be used for raising a weight or object by means of a rope (passed over the sheave of the block) a certain advantage may be obtained by the convenience of this arrangement, but there will be no gain in power and therefore a man can raise no more by this means than he could lift direct, if it were equally convenient to do so. By a proper arrangement of two or more pulleys, however, power may not only be transmitted but also *concentrated*, and it is this fact that makes the pulley block so useful a factor in mechanics. It is possible therefore, by the use of blocks to effect a gain in power, but to do this there must be a loss of time. In other words the greater the weight that can be raised by a certain expenditure of power the slower the weight will rise.

Blocks are made sometimes of wood frames with a rope "strop" and thimble eye. The sheaves are usually brass, running on a wrought-iron centre-pin, which passes through the frame and sheaves. For mechanical purposes they are more usually made with light steel or sheet-iron plates for the sides, strengthened by wrought-iron links, where the strain is most direct. The suspending hooks are connected by a strong cross-bar to the side links, and are capable of being easily moved either round their own axis, or through an angle of 90° degrees on each side. Blocks are called single, double, or treble, according to the number of sheaves which revolve on the centre-pin. Snatch, or leading blocks, are single with an opening on one side to admit a rope without passing its end through.

A simple "tackle" consists of one or more blocks rove with a single rope or "fall." When a tackle is in use, one end of the fall is made fast, and the other is hauled upon. The fixed end is called the "standing end," the other the "running" end. Each part of the rope contained between the blocks or between either extremity and a block, is called a return of the fall. To overhaul a tackle is to separate the blocks. This should always be done from the standing, and not from the movable block: to round in is to bring the blocks closer together by hauling on the fall. When a rope is passed through the sheaves of a block, it is bent to a curve suiting the radius of each sheave passed over. The sheaves should be exactly the same diameter in each pair of blocks working together. Owing to the stiffness of the rope, and friction of sheaves on the pin, the theoretical power is considerably reduced. The weight any system of blocks will lift is found by multiplying the power by the number of ropes attached to the movable block, including the standing end if fixed to it. For example, suppose we have 3 sheaves in use in each block, then the additional power acquired would be (theoretically) 6. The average additional power required for each sheave to compensate for friction is found to be about roughly 10 per cent. With 3 sheaves in use this would be 10×3, or 30 per cent. Therefore, to raise a a weight of one ton, a power of $\frac{2240}{3} + 1{\cdot}3$ lb. = 970 lb. would be required. In hauling on a fall, men exert a pull of about 80 lb., or half their weight under favourable circumstances. In this case the least number of men required would be—

$$\frac{970}{80} = 12\tfrac{1}{10}, \text{ or say 13 men.}$$

Therefore, in calculating the advantage gained by using blocks, $\frac{1}{10}$ of the weight to be lifted must be added for every sheave in use. Suppose it is required to lift a weight of 12 tons with a pair of treble-sheaved blocks, threaded with a 5-in. rope, the theoretical gain of power is 6 to 1, and the power required will be $\frac{1}{6}$ of 12; the

total resistance to be overcome, which is compounded of W, the weight to be raised, plus the resistance arising from stiffness of rope, and friction. Therefore we have $W + \frac{1}{10} W$ for each sheave in use. Now 6 sheaves are in use, therefore, $R = W + \frac{6}{10} W$.

$$P \text{ the power} = \frac{R}{6} = \frac{W + \frac{6}{10} W}{6}.$$

If 12 tons have to be lifted we have—

$$P = \frac{12 + \frac{6}{10} \text{ of } 12}{6} = 3\tfrac{1}{5}.$$

A good rule for calculating the "safe working" strength of a new rope, of white hemp, is to square the circumference in inches, and divide by 8. For instance, the safe working strength of a 5-in. rope would be $\frac{(5)^2}{8} = 3\frac{1}{8}$ tons. As another example we will calculate what weight can be raised by a "tackle" consisting of 2 treble blocks, rove with a fall of 6-in. rope, without exceeding the working strength of the rope. Here we have by formula

$$(1)\ \frac{(6)^2}{8} = 4\tfrac{1}{2} \text{ tons}$$

as the maximum strain on the running end of the "fall." Then $P = 4\frac{1}{2}$ tons, and $6\,P = R = 27$ tons, as the theoretical weight. For each sheave in use we must deduct $\frac{1}{10}$ of 27, or $2\frac{7}{10}$ for friction. Then, as we have 6 sheaves in use, $6 \times 2\frac{7}{10} = 16\frac{2}{10}$, as the total amount to be deducted from the theoretical gain, leaving as the actual power $27 - 16\frac{2}{10}$ or $10\frac{8}{10}$ tons.

The following table gives the observed ratio of useful to theoretical work done in different tackles with white rope fall.

If anything the table gives a higher efficiency than would be obtained in ordinary use it is highly necessary to keep blocks in good order, to see that all the parts are sound, that the sheaves are quite free on the pin and properly lubricated. Time spent in attending to these important details is well spent, as the friction on badly lubricated sheaves reduces their efficiency very much. Sometimes in using blocks it is found that they twist, and cause the rope to ride against itself, new rope especially. To prevent this twisting, a bar is sometimes placed through a part of the blocks, or at right angles to the "returns" close to the block. One of the best plans is to lash a handspike across the block; a light line may be lashed to each end and act as guys. This twisting of the tackles during use is a constant source of annoyance and waste of power often at a time when the power is wanted. It has been found by experiment that if the blocks are allowed to twist one complete turn, the power required to overcome friction will be increased 40 per cent.

Theoretical Power of Tackle.	Percentage of Useful Work.	Value of P.
Single	90 per cent.	1·1 w
2 : 1	81·0 „	0·62w
3 : 1	75·0 „	0·45w
4 : 1	68·0 „	0·37w
5 : 1	61·5 „	0·32w
6 : 1	59·0 „	0·28w

The following are examples of common arrangements by which an increase of power is obtained.

Fig. 180. In this the lower pulley is movable. One end of the rope being fixed, the other must move twice as fast as the weight, and a corresponding gain of power is consequently effected.

Fig. 181. Blocks and tackle. The power obtained by this contrivance is calculated as follows: Divide the weight by double the number of pulleys in the lower block; the quotient is the power required to balance the weight.

Fig. 182 represents what are known as White's pulleys, which can either be made with separate loose pulleys, or a series of grooves can be cut in a solid block, the diameters being made in

proportion to the speed of the rope; that is 1, 3, and 5 for one block, and 2, 4, and 6 for the other. Power as 1 to 7.


FIG. 180.


FIG. 181.


FIG. 182.

Figs. 183, 184 are what are known as Spanish bartons.

Fig. 185 is a combination of two fixed pulleys and one movable pulley.


FIG. 183.


FIG. 184.


FIG. 185.

Figs. 186 to 189 are different arrangements of pulleys. The following rule applies to these pulleys: In a system of pulleys where each pulley is embraced by a cord attached at one

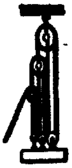


FIG. 186.


FIG. 187.

end to a fixed point, and at the other to the centre of the movable pulley, the effect of the whole will be the number 2, multiplied by itself as many times as there are movable pulleys in the system.

The Differential Pulley-Block.—This useful form of block is a modern adaptation of an old principle—a principle


FIG. 188.


FIG. 189.

not hitherto applied in practice. Fig. 190 will serve to describe the working. The upper, fixed, block has a double

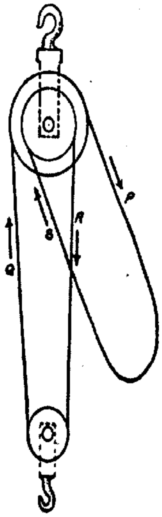


FIG. 190.

sheave; two sheaves it might be said joined side by side, so that both turn together, but it will be noticed that one sheave is smaller than the other. The lower, loose, block is of ordinary structure except that the groove is

ridged across in a way that receives and holds the chain as it passes round. The whole of the chain is one endless piece passed over the blocks as shown, the direction in which it moves being indicated by the arrows. The power (the pull of the hands) is applied at P, and from here the action can be followed. From P the power raises Q and lowers R, but as the circumference of the sheave by which the chain Q is raised is greater than that by which R is lowered, it follows that the chain is pulled in a little faster than it is lowered out. It follows therefore that the lower pulley is thus raised gradually, and the raising of the load is due to the difference in these actions. The only object in making the chain endless is to save using a long chain which would otherwise be necessary.

One peculiarity of this pulley is that if the power chain P is released the weight does not run down or "overhaul," as it is called. It is a distinctly useful feature, both as a source of safety and the power of raising or lowering the weight to any precise degree. The lowering is effected by a light pull on S. Unfortunately this good quality is due to excessive friction and loss of power, this amounting to more than half the power expended. Were it less than half overhauling would occur. Owing to the considerable friction all wearing parts must be made very hard, or the wear and tear will be excessive. The mechanical efficacy of this pulley is from six to seven-fold, a man being able to raise six to seven times the weight he could raise unaided.

PUMPS, SIPHONS, AND DEVICES FOR RAISING LIQUIDS.

(*See also* HYDRAULIC-RAMS, WATER SUPPLIES TO COUNTRY HOUSES, ETC.)

THE aim of this article is to describe the various contrivances employed in different industries and in everyday life both at home and abroad, for effecting the removal of liquids from one vessel or place to another. The most important liquid, of course, is water, but there are several, such as acids, whose corrosive nature renders the ordinary pump useless; and there are others, such as syrups, whose viscosity demands special provision. All these will come under notice; but not the modern pumping engines on a scale interesting only to the engineer, as these may be found in such works as those of Bjorling and Colyer. It will be convenient to divide this subject into 2 sections—pumps, and siphons.

Pumps.—Before proceeding to a description of the various forms of pump as now in use, there are many means of raising water that demand some notice.

One of the most simple methods of raising water is that adopted in the wells of English villages, this being a pair of buckets, one at each end of a rope passing over a pulley, as Fig. 191. In this the full bucket is partly counterbalanced by the empty one, the latter being pulled down to raise the former.

In Italy, use is made of a very simple yet ingenious contrivance for raising water from a well to the highest story of a house without descending for the purpose. This is outlined in Fig. 192. One end of a strong iron rod *a* is fixed to the house above the window of an upper landing or passage, the lower end being secured in the ground on the far side of the well *b*, and in a line with its centre. A ring which will slide easily over the rod is

fastened to the handle of the bucket c, to which also a cord d is attached, and carried over a pulley supported above

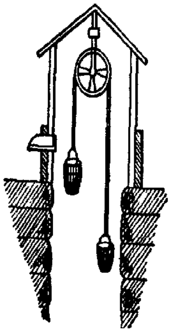


FIG. 191.

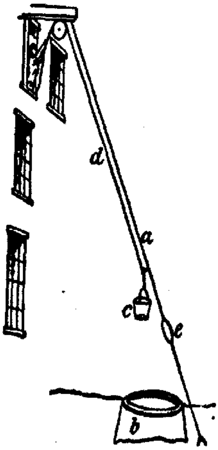


FIG. 192.

the window. When the cord d is slackened, the bucket descends in a diagonal manner till the ring reaches the stop e, which is so arranged that at this point the bucket hangs directly over the centre of the well. On still further slackening the cord d, the bucket continues to descend, but in a perpendicular direction, to the level of the water. When filled, it is simply hauled up.

A great step in advance of the pulley, for lifting heavy weights, is the windlass, a cylinder made to revolve by crank-handles attached to one or both ends. The rope should have a bucket suspended from each end, so as to be in a manner reciprocating. The Chinese windlass illustrated in Fig. 193 fur-

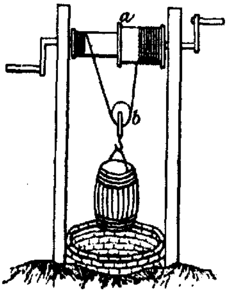


FIG. 193.

nishes the means of increasing mechanical energy to almost any extent, and is used to raise water from prodigiously deep wells. The cylinder a consists of 2 parts of unequal diameter, to the extremities of which, the ends of the rope are fastened on opposite sides, so as to wind round the 2 parts in contrary directions. As the load to be raised is suspended from a pulley b, every turn of the cylinder a raises a portion of the rope equal to the circumference of the thicker part, but at the same time lets down a portion equal to that of the thinner, consequently the weight is raised at each turn through a space equal only to half the difference between the circumferences of the 2 parts of the cylinder. Hence the action is slow, but the mechanical power saved is proportionally great.

Another way of lightening the load is illustrated in Fig. 194, and consists in replacing a portion of the cylinder *a* by a "fusee" or cone-shaped drum *b*. One end of the rope is secured to the smaller end of the cone, and the other end of the rope to the bucket. While the full bucket is at a depth in the well (implying a greater weight to raise on account of the extra rope or chain attached), the winding takes place where the circumference of the fusee is least, and as the length diminishes the rope coils round the greater circumference. Thus while the work is hardest the speed is slowest, and while the work decreases the speed increases.

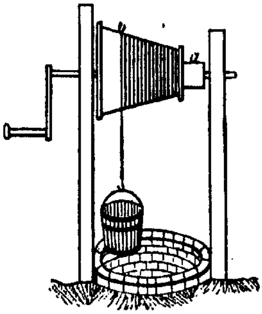


FIG. 194.

In another modification of the windlass, a cog-wheel is fixed to one end of the cylinder and moved by a pinion that is secured on a separate shaft, and turned by a crank. By proportioning the diameter of the wheel and that of the pinion (or the number of teeth on each) to the power employed, a bucket and its contents may be raised from any depth, since a diminution in the velocity of the wheel from a smaller pinion is accompanied by an increase of the energy transmitted to the cylinder, and *vice versâ*.

The crank handle of the windlass may be replaced by a drum-wheel at one end of the cylinder, of very much greater diameter than the cylinder (say a wheel 12 ft. in circumference and a cylinder 18 in.). The rope that supports the bucket is attached to the cylinder, while a second rope is made to coil round the drum. These ropes run in opposite directions, so that when the bucket is down, the cylinder rope is uncoiled and the drum rope is wound up. By taking the free end of the drum rope over the shoulder and walking away from the well, the drum rope is uncoiled and the cylinder rope is wound up, thus raising the bucket.

Sometimes, instead of coiling a second rope on the drum, this latter is made of such dimensions that a horse can work it by walking inside, constituting a tread-wheel, such as is shown in Fig. 195. The capstan-wheel is another form, which was much used in ancient times.

There have next to be considered a class of contrivances dependent on the application of simple leverage. The process illustrated in Fig. 196 is eminently easy, and very widely adopted in Eastern countries, for raising water from shallow depths (2–3 ft.) for purposes of irrigation. It is termed *mental* in Egypt. A small trench *a* is dug on the edge of the tank or stream affording a supply, and an impromptu seat *b* is made of baked earth on each side. The baling vessel *c*, usually a basket of twigs or leaves rendered water-tight by plastering with clay and cowdung, is suspended by 4 cords *d*.

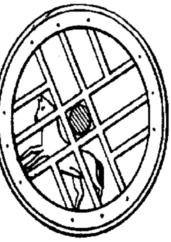


FIG. 195.

The free end of each cord is held in one hand by the operators, who, on launching the bale into the water, lean backwards towards their seats, thus assisting by their own weight in jerking

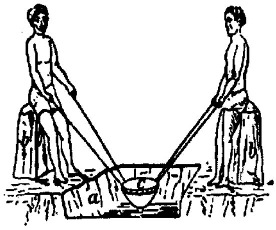


FIG. 196.

the full vessel out of the trench into a gutter cut to receive and distribute the water. In India, water is lifted in this way, some 12–16 ft. in 3 or 4 stages, by as many pairs of men, at the rate of 1800 gal. an hour.

Swinging gutters seem to have originated in the *jantu* of India, which consists of a hollow trough of wood, about 15 ft. long, 6 in. wide, and 10 in. deep, placed on a horizontal beam lying on bamboos fixed in the bank of a pond or river. One end of the trough rests upon the bank, where a gutter is prepared to carry off the water and the other end is dipped into the water by a man standing on a stage, who plunges it in with his foot. A long bamboo with a large weight of earth at the farther end is fastened to the end of the *jantu* next the river, and, poising up the *jantu* full of water, causes it to empty itself into the gutter. This machine raises water 3 ft., but by placing a series of them one above another, the water may be raised to any height. Water is thus conveyed over rising ground to the distance of more than a mile. Fig. 197 shows the mode of working a single gutter, without the aid of a lever pole. *a* is a trough whose open end *b* rests on the bank over which the water is to be elevated; the other end *c* is closed to retain the water entrapped by raising it. Fig. 198 represents an improvement, being a double gutter *a* placed across a trough *b* to receive the water. The gutter *a* is divided by a partition in the centre, on each side of which partition holes are made in the floor of the gutter to let out the water into *b*. Fig. 199 is a further development, termed a pendulum or set of swinging gutters, raising water by their pendulous motion. The terminations at bottom are scoops, and at the top are open pipes; intermediate angles are formed with boxes and flap-valve, each connected with two branches of pipe.

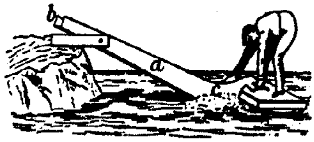


FIG. 197.

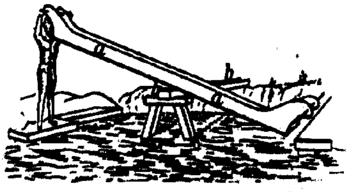


FIG. 198.

The so-called Dutch scoop, Fig. 201, is much used in Holland for raising water over low dykes. It is a kind of box shovel *a*, suspended by cords *b* from a

triangular frame *c*, and worked by an operator standing on the plank *d*, and thrusting the scoop into the water by means of the handle *e*.

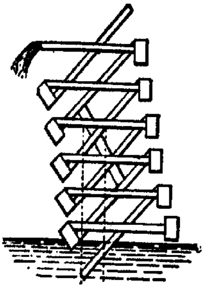


FIG. 199.

Perhaps the most widely used contrivance for drawing water from wells is that shown (in one of its many forms) in Fig. 200. It is the "swape,"

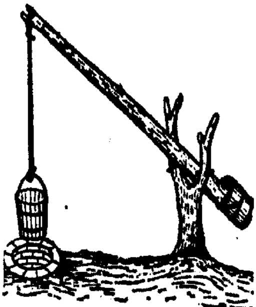


FIG. 200.

"sweep," or "swip" of English chroniclers since Anglo-Saxon times, and is now known to Australian gold-diggers as a "hand whip," the term being probably a corruption of "swip"; it is the *shadoof* or *shadouf* of Egypt. Its numerous modifications throughout the world differ only in minor details; the leading principle in all is that the counterpoise shall be about equal to the weight to be raised. In Japan,

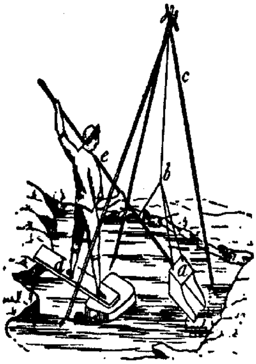


FIG. 201.

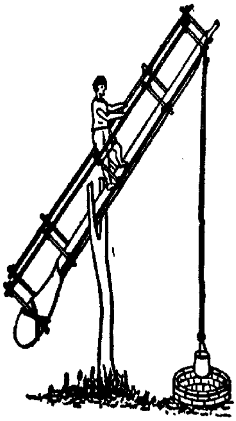


FIG. 202.

ropes are attached to the counterpoise for pulling down when elevating the bucket.

The Hindoos use a modified form of swape, Fig. 202, in which a man's

weight is utilised in raising the bucket. The lever is a split tree-trunk, ridged to form steps, and provided with a bamboo railing. As the man walks to and fro, the arm carrying the bucket is alternately lowered and raised, a second man emptying the bucket as fast as it rises. This is termed a *paecottah* or *picota* in Bengal.

Scoop-wheels assume several different forms, but consist essentially of a number of semicircular partitions between the closed sides of a wheel, extending from the axle to the circumference, as in Fig. 203, which is

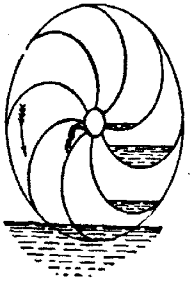


FIG. 203.

the pattern used in draining the Lincolnshire fens. As the wheel revolves in the direction of the arrow, the extremities of the partitions dip into the water and scoop it up; and as they ascend, they discharge into a trough placed under one end of the shaft, which is hollowed into as many compartments as there are partitions or scoops.

The Chinese scoop-wheel has a number of buckets attached to the periphery of a huge wheel, which is composed of 3 bamboo rings of unequal diameter, arranged so as to form a frustum of a cone, the smallest ring to which the open ends of the buckets (sections of bamboo 4 ft. long and 2-3 in. diam.) are attached, being next the bank over which the water is conveyed. By this arrangement, the contents of the buckets are necessarily discharged into the gutter as they pass the end of it. When employed to raise water from running streams, they are propelled by the current in the usual way—the paddles being formed of woven bamboo. The size of these wheels varies from 20 to 70 ft. in diameter. Some raise over 300 tons of water per 24 hours, or 150 tons 40 ft. high in the same time. Being built almost exclusively of bamboo, they combine economy, strength, lightness, and efficiency in a wonderful degree.

In the Egyptian *noria*, instead of vessels being attached to the wheel, the wheel rim itself is made hollow and divided into compartments, as seen in the section shown in Fig. 204. The

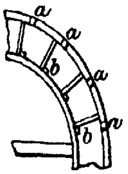


FIG. 204.

water enters through the openings *a* in the rim and escapes from those *b* in the side.

The Spanish wheel is a very light framework disc having a series of pots secured to the periphery. Its most remarkable feature is that motion is given to the wheel by a system of spokes on its axle working into other spokes on a vertical shaft—one of the earliest forms of cog-wheel.

The fault common to all the wheels hitherto described is that they begin to discharge before reaching the channel provided for the reception of the water, and waste power in carrying much of the water higher than it is required. These two defects are well remedied in the Persian wheel, by suspending the buckets so that they are free to swing, thus hanging per-

pendicularly throughout their course, until they reach the receiving trough, when they are made to tilt and discharge their contents at once by coming into contact with a stop on the trough. Fig. 205 illustrates another form of

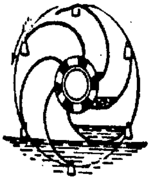


FIG. 205.

Persian wheel having both scoops and buckets. It has a hollow shaft and curved floats, at the extremities of which are suspended buckets or tubs. The wheel is partly immersed in a stream acting on the convex surface of its floats; and as it is thus caused to revolve, a quantity of water will be elevated by each float at each revolution, and conducted to the hollow shaft, at the same time that one of

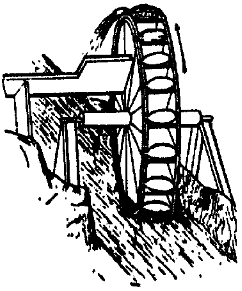


FIG. 206.

the buckets carries its fill of water to a higher level, where it is emptied by coming into contact with a stationary pin placed in a convenient position for tilting it.

In Fig. 206 is represented a machine of ancient origin, still employed on the river Eisach, in the Tyrol, for raising water from the stream. The current keeping the wheel in motion, the pots on its periphery are successively immersed, filled, and emptied into a trough above the stream.

The bucket wheel being incapable of reaching water at any considerable depth, led to the adoption of a modified form, called a chain of pots, the buckets being attached to chains working over the wheel instead of to the wheel itself. In Egypt under the name of *sakia*, this machine is in common use, and its employment extends throughout Spain and the East generally, power being applied by a vertical shaft and cog-wheels, moved by bullocks. It is nothing less than a modern "elevator" worked by animal power instead of steam.

Another form of elevator or chain pump is illustrated in Fig. 207, lifting

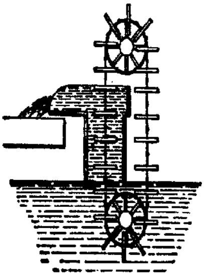


FIG. 207.

water by continuous circular motion. Wooden or metallic discs carried by an endless chain, are adapted to a water-tight cylinder, and form with it a succession of buckets filled with water. Power is applied at the upper wheel.

The chain pump known as the Chinese or Californian pump, represented in Fig. 208, is in common use in alluvial gold diggings in America and Australia. A rectangular box, about 10 in. by 8 in. inside measurement, and varying from 10 to 30 ft. long, according to

need, is traversed by an endless flexible band or belt of canvas, on one side of which are securely fixed at intervals wooden discs nearly as large as the inside of the box. The lower end of the box is furnished with a roller, around which the belt passes, and is immersed in the water to be raised from the pit, while the upper end delivers the water into a trough or launder, by which it is carried away. At the upper end the belt passes round a second roller or drum, which is made to revolve by either hand- or water-power. In *Fig.* 208 is shown one driven by a water-wheel: *a* is a flat wooden pipe or box, open at both ends, forming the pump; *b*, the pump-belt, carrying the wooden stops, faced with leather, called the buckets or suckers *d*; *c*, the ends of the ends of the belts joined together by lacing; *h*, the drum fixed on the axle of the water-wheel *w* and turning with it; *i*, entrance of water to be pumped up; *e*, exit of same; *f*, launder or race to convey the water from the pump and wheel clear of the working; *g*, sluice-box set in a head-race to bring the water necessary for driving the wheel. The Chinese diggers make even the belt of wood, hinging short sections together by wooden pins.

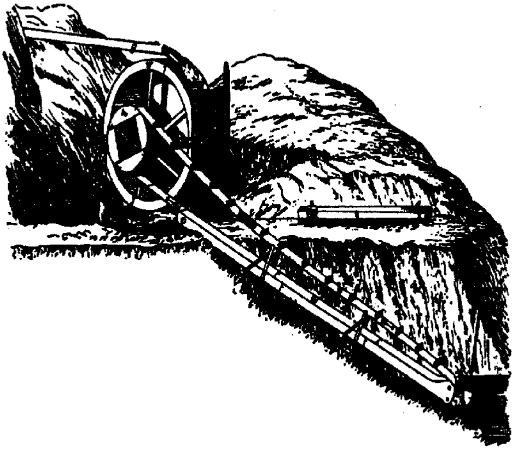


FIG. 208.

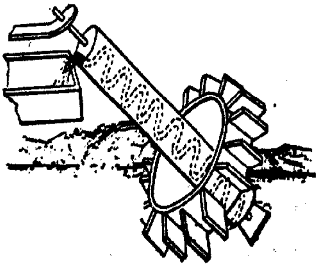


FIG. 209.

An application of the Archimedes screw to the raising of water is shown in Fig. 209, the supply stream being the motive power. The oblique shaft of the wheel has extending through it a spiral passage, the lower end of which is immersed in water, and the stream, acting upon the wheel at its lower end, produces its revolution, by which the water is conveyed upward continuously through the spiral passage, and discharged at the top.

A reciprocating lift for wells is indicated in Fig. 210. The top part represents a horizontal wind-wheel on a shaft which carries a spiral thread. The coupling of the latter allows a small vibration, that it may act on one worm-wheel at a time. Behind the worm-wheels are pulleys, over which passes a rope which passes a bucket at each extremity. In the centre is a vibrating

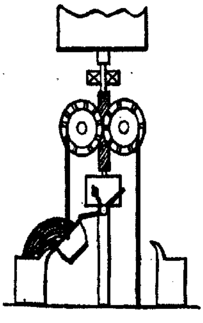


FIG. 210.

tappet, against which the bucket strikes in its ascent, and which, by means of an arm in a step wherein the spiral and shaft are supported, traverses the spiral from one wheel to the other, so that the bucket which has delivered its water is lowered, and the other is raised.

Fairbairn's baling scoop for elevating water short distances is illustrated in Fig. 211. The scoop is connected by a pitman with the end of a lever or of a beam of a single-acting engine. The distance of the lift may be altered by

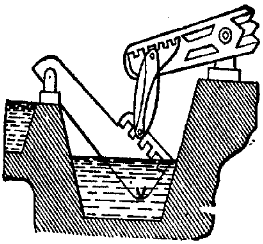


FIG. 211.

placing the end of the rod in the notches shown.

Brear's bilge ejector, for discharging bilge-water from ships, or for raising and forcing water under various circumstances, is represented in Fig. 212;

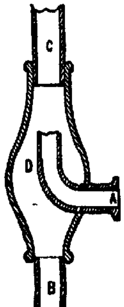


FIG. 212.

D is a chamber having attached a suction-pipe B and discharge-pipe C, and having a steam-pipe entering at one side, with a nozzle directed towards the discharge-pipe. A jet of steam entering through A expels the air from D and C, produces a vacuum in B, and causes water to rise through B and

pass through D and C in a regular and constant stream. Compressed air may be used as a substitute for steam.

Fig. 213 is another apparatus operating on the same principle, and is termed Lansdell's steam siphon pump;

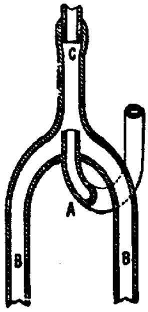


FIG. 213.

A is the jet pipe; B, 2 suction-pipes having a forked connection with the discharge-pipe C. The steam-jet pipe entering at the fork offers no obstacle to the upward passage of the water, which rises in an unbroken current.

Fig. 214 is a common lift pump. In the up-stroke of the piston or bucket,

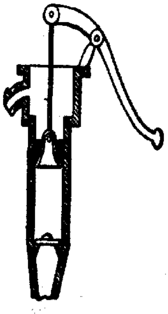


FIG. 214.

the lower valve opens and the valve in the piston shuts; air is exhausted out of the suction-pipe, and water rushes up to fill the vacuum. In the down-stroke, the lower valve is shut, the valve in the piston opens, and the water simply passes through the piston. The water above the piston is lifted up, and runs over out of the spout at each up-stroke. This pump cannot raise water over 30 ft. high.

Fig. 215 is an ordinary force-pump with 2 valves. The cylinder is above

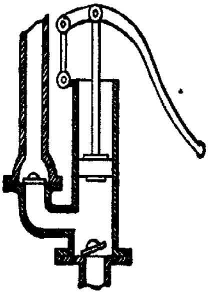


FIG. 215.

water and is fitted with a solid piston; one valve closes the outlet-pipe and the other the suction-pipe. When the

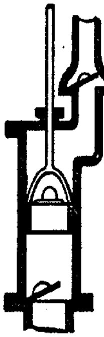


FIG. 216.

piston is rising, the suction-valve is open, and water rushes into the cylinder, the outlet-valve being closed. On

the descent of the piston, the suction-valve closes, and water is forced up through the outlet-valve to any distance or elevation.

Fig. 216 is a modern lift-pump operating in the same manner as that shown in Fig. 215, except that the piston-rod passes through the stuffing-box, and the outlet is closed by a flap-valve opening upwards. Water can be lifted to any height above this pump.

Fig. 217 is a force-pump similar to that in Fig. 215, with the addition of an air-chamber to the outlet, to produce a constant flow. The outlet from the air-chamber is shown at 2 places, from either of which water may be taken. The air is compressed by the water during the downward stroke of the piston, and expands and presses out the water from the chambers during the up-stroke.

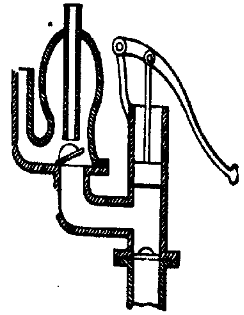


FIG. 217.

Fig. 218 is a double-acting pump. The cylinder is closed at each end, and the piston-rod passes through the stuffing-box on one end; the cylinder has 4 openings covered by valves, 2 for admitting water and 2 for its discharge. A is the suction-pipe; B, discharge-pipe. When the piston moves down, water rushes in at suction-valve 1 on the upper end of the cylinder, and that below the piston is forced through valve 3 and discharge-pipe B. On the piston ascending again, water is forced through discharge-valve 4 on the upper end of the cylinder, and water enters the lower suction-valve 2.

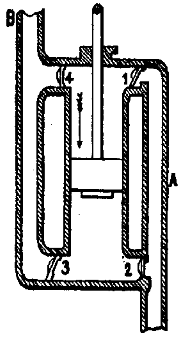


FIG. 218.

Fig. 219 is a double lantern-bellows pump. As one bellows is distended by the lever, air is rarefied within it, and water passes up the suction-pipe to fill the space; at the same time the other bellows is compressed, and expels its contents through the discharge-pipe, the valves working the same as in the ordinary force-pump.

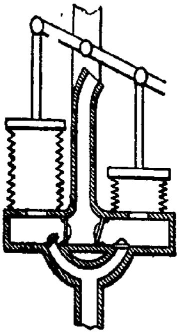


FIG. 219.

Fig. 220 is an old rotary pump. The

lower aperture is the entrance for water, and the upper for its exit. The central part revolves with its valves, which fit accurately to the inner surface of the outer cylinder. The projection shown in the lower side of the cylinder is an abutment to close the valves when they reach that point.

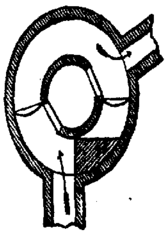


Fig. 220.

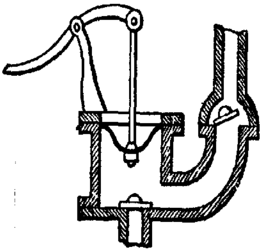


Fig. 222.

Fig. 221 is Cary's rotary pump. Within the fixed cylinder is placed a receiving drum B, attached to an axle, a heart-shaped cam *a*, surrounding the axle, being also fixed. Revolution of the drum causes sliding pistons *c* to move in and out, in obedience to the

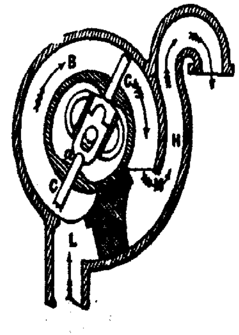


Fig. 221.

form of the cam. Water enters and is removed from the chambers through the ports L M as indicated by arrows. The cam is so placed that each piston is, in succession, forced back to its seat when opposite E, and at the same time the other piston is forced fully against the inner side of the chamber, then driving before it the water already there into the exit-pipe H, and drawing after it through the suction-pipe the stream of supply.

In Fig. 222 a flexible diaphragm is employed instead of bellows, the valves being arranged as usual.

Having described the best known means of raising water under various circumstances, there remains to enter with more detail into the construction, capacity, and working of the 3 kinds of common pump in everyday use—i.e. (1) the lift-pump for wells not over 30 ft. deep, (2) the lift and force for wells under 30 ft. deep, but forcing the water to the top of the house, and (3) the lift and force for wells 30–300 ft. deep.

The working capacity of a pump is governed by the atmospheric pressure which roughly averages 15 lb. per sq. in. It is also necessary to remember that 1 gal. of water weighs 10 lb. The quantity of water a pump will deliver per hour depends on the size of the working barrel, the number of strokes and the length of the stroke. Thus if the barrel is 4 in. diam., with a 10-in. stroke, piston working 30 times a minute, then the rule is—square the diameter of the barrel and multiply it by the length of stroke, the number of strokes per minute, and the number of

minutes per hour, and divide by 353, thus:—

$$\frac{16 \text{ in.} \times 10 \text{ in. stroke} \times 30 \text{ strokes} \times 60 \text{ minutes}}{353}$$

= 815 gal. per hour. About 10 per cent. is deducted for loss. The horse-power required is the number of lb. of water delivered per minute, multiplied by the height raised in ft., and divided by 33,000. Thus:—

$$\frac{815 \text{ gal.} \times 10 \text{ lb.} \times 30 \text{ ft. lift}}{33{,}000 \times 60}$$
$$= \cdot 123 \text{ or say } \tfrac{1}{8} \text{ H.P.}$$

Fig. 223 shows a vertical section of the simple lift-pump. *a* is the working barrel, bored true, to enable the piston or bucket *b* to move up and down, airtight. The usual length of barrel in a common pump is 10 in. and the diameters are 2, 2½, 3, 3½, 5 and 6 in.; a 3-in. barrel is called a 3-in. pump. The stroke is the length of the barrel; but a crank, 5-in. projection from the centre of a shaft, will give a 10-in. stroke at one revolution; but in the common pump shown, use is made of a lever pump-handle, whose short arm *c d* is about 6 in. long, and the long arm or handle *d e* is usually 36 in., making the power as 6 to 1; *f* is the fulcrum or prop. Improved pumps have a joint at *f*, which causes the piston to work in a perpendicular line, instead of grinding against the side of the barrel. The head *g* of the pump is made a little larger than the barrel, to enable the piston to pass freely to the barrel cylinder; in wrought-iron pumps, the nozzle is riveted to the heads, and unless the head is larger than the barrel these rivets would prevent the piston from passing, and injure the leather packing on the bucket. The nozzle *h* fixed at the lower part of head, is to run off the water at each rise of the piston. There is one valve *i* at the bottom of the barrel, and another in the bucket *b*.

The suction-pipe *k* should be ⅔ the diameter of the pump barrel. A rose *l* is fixed at the end of the suction-pipe to keep out any solid matter that might be drawn into the pump and stop the action of the valves. The suction-pipe must be fixed with great care. The joints must be air-tight:

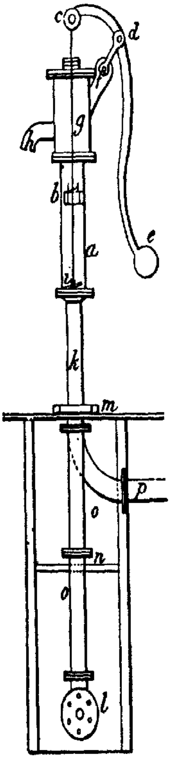


FIG 223.

if of cast flange-pipe, which the most durable, a packing of hemp, with white and red lead, and screwed up with 4 nuts and screws, or a washer of vulcanised rubber ⅛ in. thick, with screw bolts, is best. If the suction-pipe is

of gas-tube, the sockets must all be taken off, and a paint of boiled oil and red-lead be put on the screwed end, then a string of raw hemp bound round and well screwed up with the gas tongs, making a sure joint for cold water, steam, or gas.

Many plumbers prefer lead pipe, so that they can make the usual plumbers' joint. The tail *m* of the pump is for fixing the suction-pipe on a plank level with the ground. Stages *n* are fixed at every 12 ft. in a well; the suction-pipe is fixed to these by a strap staple, or the action of the pump would damage the joints. There are two plans for fixing the suction-pipe; (1) in a well *o* directly under the pump; (2) the suction-pipe *p* may be laid in a horizontal direction, and about 18 in. deep under the ground (to keep the water from freezing in winter) for almost any distance to a pond, the only consideration being the extra labour of exhausting so much air. In the end of such suction-pipe *p* it is usual to fix an extra valve, called a "tail" valve, to prevent the water from running out of the pipe when not in use. The action is simply explained. First raise the handle *e*, which lowers the piston *b* to *i*; during this movement the air that was in the barrel *a* is forced through the valve in the piston *b*; when the handle is lowered, and the piston begins to rise, this valve closes and pumps out the air; in the meantime the air expands in the suction-pipe *k*, and rises into the barrel *b* through the valve *i*; at the second stroke of the piston this valve closes and prevents the air getting back to the suction-pipe, which is pumped out as before. After a few strokes of the pump handle, the air in the suction-pipe is nearly drawn out, creating what is called a vacuum, and then as the water is pressed by the outward air equal to 15 lb. on the sq. in., the water rises into the barrel as fast as the piston rises; also the water will remain in the suction-pipe as long as the piston and valves are in proper working order.

The following table of dimensions for hand-worked simple lift-pumps will be found useful:—

Height for Water to be raised.	Diam. of Pump Barrel.	Water delivered per Hour at 30 Strokes per Min.	Diam. of Suction Pipe.	Thickness of Well Rods for Deep Wells.
ft.	in.	gal.	in.	in.
14	6	1640	4	1
20	5	1140	3	1
30	4	732	2½	7/8
40	3½	555	2½	3/4
50	3	412	2	3/4
75	2½	260	2	5/8
100	2	183	1½	5/8

Fig. 224 shows a lift- and force-pump suitable for raising water from a well 30 ft. deep, and forcing it to the top of a house. The pump barrel *a* is fixed to a strong plank *b*, and fitted with "slings" at *c* to enable the piston to work parallel in the barrel, a guide rod working through a collar guiding the piston in a perpendicular position. *d* is the handle. The suction-pipe *e* and rose *f* are fixed in the well *g* as already explained. At the top of the working barrel is a stuffing-box *h*, filled with hemp and tallow, which keeps the pump-rod water-tight. When the piston is raised to the top of the barrel, the valve *i* in the delivery-pipe *k* closes, and prevents the water descending at the down-stroke of the piston. The valve in the bucket *l*, also at *m* in the barrel *a*, is the same as in the common pump. The pipe *k* is called the "force" for this description of pump.

Fig. 225 shows a design for a deep well pump, consisting of the usual fittings—viz. a brass barrel *a*, a suction-pipe with rose *b*, rising main pipe *c*, well-rod *d*, wooden or iron stages *e f g*, and clip and guide pulleys *h*. The well-rod and the rising main must be well secured to the stages, which are fixed every 12 ft. down the well. An extra strong stage is fixed at *i*, to carry

the pump—if of wood, beech or ash, 5 ft. × 9 in. × 4 in.; the other stages may be 4 in. sq.

The handle is mounted on a plank *k* fitted with guide slings, either at right angles or side-ways to the plank. The handle *l* is weighted with a solid ball-end at *m*, which will balance the well-rod fixed to the piston. By fixing the pump barrel down the well about 12 ft. from the level of the water, the pump will act better than if it were fixed 30 ft. above the water, because any small wear and tear of the piston does not so soon affect the action of the pump, and therefore saves trouble and expense, as the pump will keep

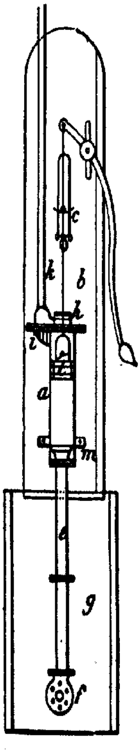


FIG. 224.

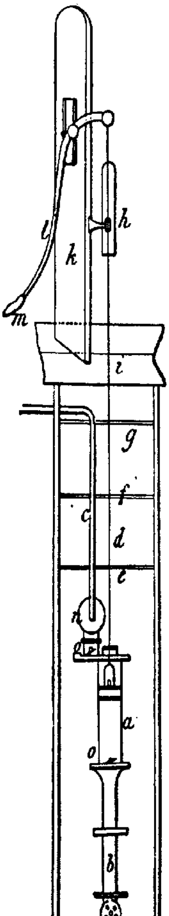


FIG. 225.

in working order longer. It is usual to fix an air-vessel at *n*. The valves *o* are similar to those already described. In the best-constructed pumps, manholes are arranged near the valves to enable workmen to clean or repair the same, without taking up the pump. Every care should be given to make strong and sound joints for the suction-pipe and delivery-pipe, as the pump cannot do its proper duty should the pipes be leaky or draw air.

To find the total weight or pressure of water to be raised from a well, reckon from the water level in the well to the delivery in the house tank or elsewhere. For example, if the well is 27 ft. deep, and the house tank is 50 ft. above the pump barrel; then you have 77 ft. pressure, or about 33 lb. pressure per sq. in. That portion of the pipe which takes a horizontal position may be neglected. The pressure of water in working a pump is according to the diameter of the pump barrel. Suppose the barrel to be 3 in. diam., it would contain 7 sq. in., and say the total height of water raised to be 77 ft., equal to 33 lb. pressure, multiplied by 7 sq. in., is equal to 231 lb. to be raised or balanced by a pump handle; then if the leverage of the pump handle were, the short arm 6 in. and long arm 36 in., or as 6 to 1, you have 46 lb. power on the handle to work the pump, which would require 2 men to do the work, unless you obtained extra leverage by wheel work. When the suction- or delivery-pipe is too small, it adds enormously to the power required to work a pump, and the water is then called "wire-drawn." When pumps are required for tar or liquid manure, the suction- and delivery-pipe should be the same size as the pump barrel, to prevent choking.

(*a*) In arranging a pumping installation every care must be taken in deciding the size of the suction-pipe; also of the delivery or rising main, if there is one. This latter pipe is of importance, as if too small it can add greatly to the work of pumping. The least size of pipe for a rising main is one-half the diameter, which is one-fourth the area, of the pump barrel. Thus, a 3-in. pump should have a 1½-in. rising-main from it, and the same rule applies in finding the size of the suction-pipe. In the case just stated the suction-pipe would also be 1½ in. It must not be thought that because the pump bucket raises a quart of water at each stroke that the quart of water will pass up the pipes just the same, whatever their size. In practice it will be seen that a given quantity of water passing up a 1-in. pipe has to travel at least four times as quickly as the same quantity up a 2-in. pipe, owing to the areas of these pipes being as 4 and 1. The result is greatly increased frictional resistance, so great as to be a serious factor. No harm results, but rather the reverse, if pipes of larger size than the rule just laid down are used, but they should never be smaller than one-half the diameter of the pump barrel.

In calculating pump duties, it may be estimated that one man, with a 2½-in. pump, can raise 180 gal. of water per hour. With a 3-in. pump this quantity would be increased one-half if the man made as many strokes per hour, but this he would not do. A 3-in. pump, however, is best (for one-man power) if the lift is a light one, say 30 ft. from the surface of the water in the well to the highest point of the delivery-pipe, but when higher than this the 2½-in. pump will be found to yield about as much as a 3-in. and with less apparent labour. One-man power is considered to be one-seventh of a horse-power, which would credit the man with raising 28,286 gal. 1 ft. high, or, say, 470 gal. 60 ft. high. This, however, does not work out correctly in practice, and seldom more than one-fourth of these figures can be relied on.

A retaining valve is sometimes put on the end of the suction-pipe in the well, the object of this being to prevent the water running back out of the pipe when the pump's working parts become a little unsound. It is a pro-

vision generally recommended with long suction-pipes, there being a considerable horizontal length in the pipe, but failing this the valve is best absent. It offers a resistance to the flow of water, and, like all such valves, it gets out of order in time, and its position makes it awkward to get at.

An important detail, much neglected, is to see that the suction pipe has a regular fall (or it may be quite horizontal where necessary) from the pump to well. It must not have dips, nor high places, for if these exist, air will collect in them and cause much more trouble than the inexperienced can well believe. Where a rise in this pipe is unavoidable, there should be a stand pipe on its highest part with a soundly-fitting stop-cock. A retaining valve would require to be put on the end of the suction pipe, so that on opening the cock and pouring water in, the collected air would be displaced, and the pipe quite filled with water. On shutting the cock, the pumping should be satisfactory and normal.

When the rising main from a pump exceeds 15 to 18 ft. in height, there should be an air-vessel to it to minimise shock. This would particularly apply to single-barrel pumps in which the water is stopped at each stroke, but it should be considered requisite with all pumps, whatever the number of barrels, if the rising main is at all high. Even with comparatively low elevations the air-vessel is beneficial in preventing shock, reducing labour and wear and tear. The air-vessel is put either on the pump or on the rising main close to the pump.

Deep-well pumps are those that are fixed below the ground level and operated by rods and gear at ground level. All pumps must be within 28 ft. of the water, therefore if the water is 40 ft. below ground level, the pump must be at least 12 ft. down, preferably more. As a rule, when the pump has to be fixed down the well it is put within about 10 ft. of the water. This is best for general reasons, besides making allowance for a fall in the water level.

In deciding what size of deep-well pump is best suited for one-man power, neglecting for the moment the amount of water required,* a simple calculation is all that is necessary. Let it be supposed that the perpendicular distance from the well water to the delivery outlet in the cistern is 70 ft. The pressure of water in pipes is 1 lb. per sq. in. for each 2 ft. 4 in. in height, therefore a 70 ft. column will exert a pressure of 30 lb. on each sq. in. of the area of the pump barrel. A 3-in. pump has an area of say 7 sq. in., which will make a total pressure of 210 lb. The handle of the pump is arranged on the principle of the lever, the end that is held being probably 6 times as long as the end to which the pump rod is attached. This will cause a reduction in pressure to 35 lb. per stroke, but as 25 lb. per stroke is considered sufficient for one man continuously pumping, a 3-in. pump would be too large. A $2\frac{1}{2}$-in. pump would therefore best suit the case, the area of this being but 5 sq. in., little more than $\frac{2}{3}$ of the 3 in. As a rule the deep-well pump is best operated by a wheel action, the pump and its wheel being mounted on a board.

A rule for finding the size of pump to raise a given quantity of water, is as follows—

$$D = \sqrt{\frac{G}{\cdot 034 \times L \times S}}$$

where

D = diameter of pump in inches
G = gal. raised per min.
L = length of stroke in ft.
S = number of strokes per min.
$\cdot 034$ = the contents, in gal., of 1 ft. of 1-in. pipe.

In fixing a deep-well pump, it should be placed on and firmly secured to a "stage," and this, if of wood, should

* For residence work the amount would probably be such as one man could furnish, and the only calculation needed would be to discover the size of pump best suited for his strength.

be of oak. If the well is deep enough there should be stages—skeleton platforms—every 10 ft. The pump is fixed near the side of the well, not centrally, and this lowest stage should be boarded over with loose boards. The stages above are merely cross-pieces, and these carry the roller guides for the pump rods, and the rising main is also secured to them. Modern engineers use wrought and cast-iron cross stages, in place of oak.

(*b*) *Tube-Well Pumps.*—What is known as the Abyssinian tube-well (due to its prominent use in the Abyssinian campaign) is merely a wrought-iron tube driven into the earth, a pump of any ordinary design being attached at the top. Where they can be employed, they save considerable expense as against ordinary well-sinking. That it is not a device only suited for small purposes may be judged by its use at the Burton Breweries, where there are some fifty 3-in. tube-wells raising 2,000,000 gal. of water daily. Unfortunately the tube-well is not suited for such soils as clay, very fine sand, marl or loam, but in gravel, coarse sand, chalk, and some modifications of these, it does well.

Fig. 226 affords all the details of the well, showing the lower end of the tube underground.

The well, if it may be called such, consists of a sufficient number of lengths of ordinary good quality wrought tube with socket joints. The joints, as they are made, must be quite sound and water- (or rather air-) tight. The lowest end length of the tube, the first to be driven in the ground is heated and hammered to a point (or these pointed ends may be purchased), and a number of holes must be drilled in this length as shown.

The method of driving is simple, the chief tools being the pulleys, the "monkey," and the "clamp." These are embodied in Fig. 227. Assuming that the pointed tube has been inserted in the ground (by digging or driving with a heavy wooden tool), a length of pipe is then connected (to the pointed end piece), and on this pipe the clamp is secured at a suitable point. Following the clamp the monkey (weight) is slipped on, and then the pulleys are secured. By pulling the ropes shown passing over the pulleys the monkey is raised, and then, on suddenly releasing the ropes,

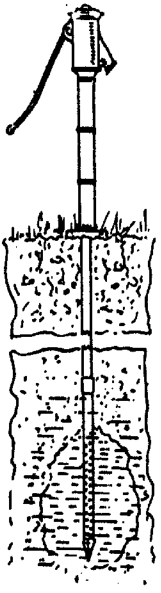


FIG. 226.

this weight falls and delivers a blow on the clamp. The clamp being securely attached to the pipe, the successive blows delivered have the effect of driving the pipe into the ground. When the pipe has been driven down until the clamp is at or near the earth, the clamp and pulleys must be loosened, raised and re-secured at a higher point and the ramming continued. It is a two-handed job,

but one man need only be an agricultural labourer.*

In doing this work first see that the pointed end is well pointed and true, and be sure that this end length is driven in true and perpendicular at the start. As soon as the tube is a few feet down, and then every 2 ft. or less, let a plummet be lowered down inside the tube to see if a water-bearing stratum has been reached.

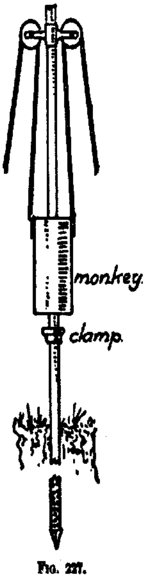


FIG. 227.

When water is reached and the pump attached, it may be necessary to resort to "priming." This means pouring some water down the tube and then working the pump-handle in short jerks. This loosens the earth around the perforated lower tube. Before the pump is attached it should be seen that the driving has not caused the perforated tube to become choked full of earth or sand. If it has, a piece of smaller tube should be put down and the pump attached to this smaller tube, water being then poured down and the pump worked to lift the earth out. When the pump is finally fixed and tried, there is almost certain to be a deal of sand or earthy material raised with the water at first. This, however, will cease as soon as a cavity has been formed in the earth, as the illustration shows.

The available quantity of water from a tube well depends on the spring or stratum that is tapped, but the following figures represent the usual limits:—

Size of Tube.	Gallons raised per Hour.
in.	
$1\frac{1}{4}$	200 to 500
$1\frac{1}{2}$	300 „ 750
2	400 „ 1300
3	1000 „ 2500
4	2000 „ 4500

The tube-well, when possible, is cheaper than a dug well. For residence work, the $1\frac{1}{4}$-in. size is usually sufficient, and to drive a 20-ft. well of this size, including all expenses and a fair quality lift-pump, will seldom exceed 5*l*. 10*s*.

Tube-wells can be sunk as deep as 80 ft., though 50 ft. is considered the limit of depth. When sunk these depths it is generally expected that the water, when struck, will rise up the tube to a sufficient height for a pump at ground level to be used, but if not then it is customary to dig a dry well down far enough, that is, until a point is reached 25 to 28 ft. above the water. The pump is then fixed in this dry well and operated as a deep-well pump.

In Figs. 228 and 229 are shown views which illustrate a successful method of obtaining large supplies of water by means of tube-wells, if the

* The ends of the tubes are screwed a little longer than usual, so that they enter the socket far enough to butt together inside. In some cases the monkey does not run on the tube, but is suspended from a tripod frame. The monkey then drops on the end of the tube, which has a heavy cap on it to take the blow.

underground water is in sufficient quantity and near enough to the surface to be raised by suction.

It consists in any number of separate driven wells, covering a considerable

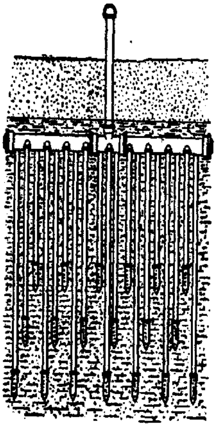
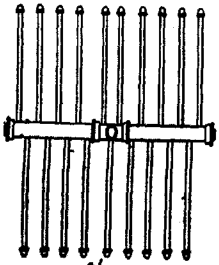


FIG. 228



plan.

FIG. 229.

area, the wells generally being driven at varying depths. These wells are all connected into a main horizontal collecting pipe of large size, which really acts as a small storage. A connection is made from this to the pumping engine. In some instances these wells are driven from the surface, but in the case shown in Figs. 228 and 229, an excavation is first made.

When water is to be found in large quantity, this method is an effective one in providing the water-supply for small towns and villages.

(c) *Wing Pumps.*—The semi-rotary or "wing" pump is an ingenious device in which a pumping action is produced by the reciprocating movement of one or more arms or wings in a circular space. An illustration will serve better than any description to show this action, and Figs. 230 and 231 are

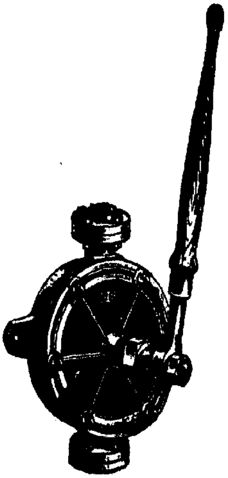


FIG. 230.

therefore given. The first illustration shows the exterior of a Wilcox pump with its handle, while the second affords particulars of the interior working parts. This illustration is of a "double acting" pump, each movement of the handle, either way, performing a pumping stroke. They are also made single-acting and

quadruple-acting. The double-acting pump is also to be had with ball valves and leather seatings—instead of flap valves—for pumping muddy or sandy water.

The illustration Fig. 231 affords all detail of the working parts, so that

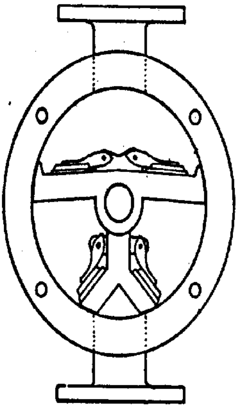


FIG. 231.

description is unnecessary. The list of capacities is as follows:—

No.	Approximate capacity per Hour.	Speed per Minute. Double Strokes.	Size of Suction and Delivery Pipes.	Height.	Diameter of Face-plate.
	gal.		in.	in.	in.
0	270	104	½	8	5
1	360	100	¾	9½	5½
2	540	88	1	10	6½
3	680	82	1¼	12	7½
4	930	80	1½	13½	8
5	1140	72	1½	14	9½
6	1500	58	1¾	15	10½
7	1800	54	2	17	12
8	2400	52	2	20	13½
9	2340	46	2½	21½	14½
10	3600	40	3	22	15
11	4300	40	3	24	17

Diaphragm Pumps.—This is another form of pump which does not rely on a plunger working in a cylinder. In this case a rubber diaphragm takes the place of the plunger, and this makes them particularly suited for raising muddy or sandy water, water containing coal debris or small gravel, also sewage. It is a broad low form of pump, but can be made odourless when pumping out cesspools, etc., by a proper fitting dome cover.

Pumps for Acids.—The chief difficulty with acids is their corrosive

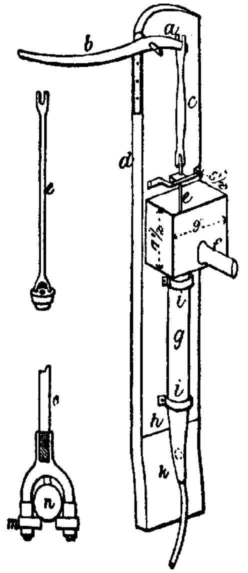


FIG. 232.

action on the materials employed in pump construction, necessitating the replacement of the ordinary materials by others less liable to destruction.

A common leaden lift-pump adapted for use with acid which is neither strong nor hot is shown in Fig. 232: *a*, wooden plank, 5 ft. × 11 in. × 2 in.; *b*, iron

handle and support; c, iron rod; d, iron stay; e, copper plunger-rod; f, leaden box with spout 1½-in. bore; g, leaden barrel, 2½-in. bore; h, iron plate; i, iron bands; k, leaden ball valve; l, leaden supply-pipe ¾-in. bore; m, rubber packing ring; n, leaden ball valve.

Doulton's stoneware force-pumps for acids, bleach liquor, alkalies, vinegar, etc., are shown in Fig. 233. They can

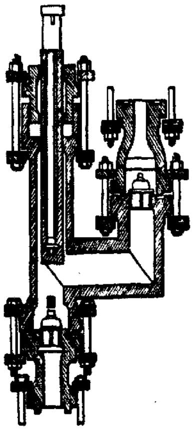


FIG. 233.

be used in connection with stoneware socket piping if required, and the various parts can be had separately in case of breakage. They range from 1½-in. bore, 6-in. stroke, raising 44 gal. per hour, to 6-in. bore, 15-in. stroke, raising 1800 gal. per hour. These pumps are arranged to work by steam power. The plunger is of stoneware, accurately ground to fit the stuffing-gland, this also being ground on the working surfaces. Asbestos is used for packing. The valves, which are of the form usually known as "butterfly valves," are ground accurately into their sittings, the rise being adjusted by the stoneware cross-bat, made in the ware above. The jointing of the parts is made by means of a circular groove and fillet fitting into each other, packed with rubber or asbestos, the flange being clipped by two sets of iron semicircles crossing each other, thus forming a continuous ring, through which the bolts and nuts pass as shown in drawing. Stoneware barrels are also carefully made for lift-pumps with rubber buckets. The difficulty of grinding the interior surface of the slider being considerable, this arrangement is not in practical use. The ram is hollow, having an iron rod for attachment passing through the centre, the end being stopped with some acid-proof material, such as sulphur. The iron parts are coated with rubber or varnish, as may be necessary for the purpose to which the pump is to be applied.

The application of compressed air to the surface of acid contained in a close vessel with an outlet is much adopted in large works. The vessel containing the acid is usually of cast iron lined with stout lead, and the air pumps are driven by steam.

A very handy contrivance for drawing small quantities of acid from carboys, etc., is known as Nichols' acid pump. This apparatus is securely fixed by a thumb-screw on a pedestal, to be readily adjustable for height. The pedestal is supported on a miniature platform (easily extemporized from an old box), which again is placed on the carboy. The principle on which the pump is constructed may be seen in Fig. 234. The body or working part of the pump consists of 3 glasses, a, and a rubber bulb b. The glasses are very carefully ground together and secured at the joints by screw couplings, making them perfectly air-tight. The two valves c are fitted to their places and carefully ground by machinery, which drives the air into the chamber between the glass cups. In use, the rubber bulb is compressed by the hand. The lower valve remains tight, and the air escapes through the upper valve. The hand, now removed from the bulb, allows it to expand, and as a vacuum is created in the chamber, the upper

valve closes, and the acid rises through the section tube into the chamber to fill the vacuum. Another compression of the bulb drives the acid up through the upper valve, and the chamber is again filled with acid; as this operation is repeated, the liquid flows from

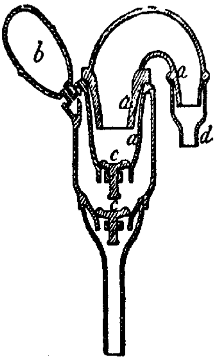


FIG. 234.

the nozzle *d* of the pump. The relative capacity of the chamber and bulb is so nicely adjusted that the acid never rises high enough in this chamber to enter the bulb. It will be noticed that an air-chamber is formed at every joint by a downward projection of the top piece; this prevents the acid from ever reaching any joint so long as the pump stands erect. A discharge-tube attached to the nozzle of the pump extends to a point just below the bottom of the carboy, so that continuous pumping for a short time will give a siphonic action which can be instantly arrested at any time by the removal of the bulb from its nipple. A metallic bulb may be substituted for the rubber one, giving greater power. By means of a metallic bulb, a large tube may be used on the siphon, which will be capable of emptying a carboy of sulphuric acid in less than 3 minutes. The pump consists of a pump and siphon, which becomes *self-acting*, after a few strokes of the bulb. Once set in motion, the acid flows until stopped. Its action is rapid and perfect. The glasses are entirely enveloped in a light cast-iron covering, and the apparatus is light, durable, and perfect in its action. Any quantity of acid can be drawn without the least danger to clothing, person, or floors, and the person using the pump may be entirely inexperienced in such matters.

Although the following device, in slightly different forms, has been in use for some time, yet the convenience of the modification shown in Fig. 235

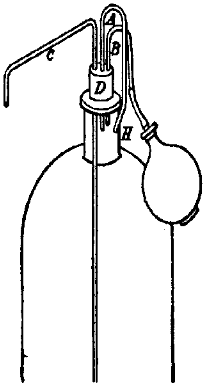


FIG. 235.

may render it worthy of description. A B C are 3 glass tubes passing through the rubber stopper D, A and B ending just below the stopper and C reaching to the bottom of the bottle. To B is attached a double-valve rubber bulb. A is so bent that while the bulb is clasped in the hand, the thumb can easily be held over the open end of A at H. Acid can then be forced out through C, and the flow may be checked instantly by removing the thumb from H. The left hand is thus left free to hold under C the vessel into which the acid is to flow. A glazed earthenware dish is placed upon

the table under C to catch the drippings. For the use of large classes of beginners in general chemistry this apparatus is well adapted, since accidents resulting from careless handling are rendered almost impossible, and both acid and time are economised. The same device may be used for carboys, the tube C being extended upward, so that an acid bottle may stand on the box beneath it, and H being kept closed by a piece of rubber tubing and a pinch cock. (L. M. Dennis in 'Amer. Chem. Jour.')

A modern pattern of Doulton's stoneware pump is shown in Fig. 236,

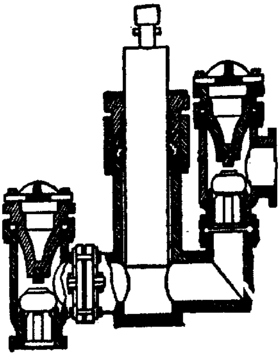


Fig. 236.

embodies all the improvements suggested by many years' practical experience. Each pump, before being supplied, is put into actual work with a 30-ft. head of water and tested as to efficiency, and so to ensure satisfactory working. They are strongly constructed of acid-proof stoneware, plunger and valves also being of this material. The valves and seatings are easily accessible by removing the valve box covers, and the lift of the valves is adjustable. In case of injury to any portion of the pump, it can be replaced at a small cost. The pumps are made in sizes to lift 240-2000 gal. per hour. They appear to be giving great satisfaction.

Pumps for Syrups.—The use of force-pumps of ordinary construction for raising cane-juice and syrups is to be condemned on the grounds of their limited capacity, the churning of the liquid and consequent admixture of air, and contamination of the

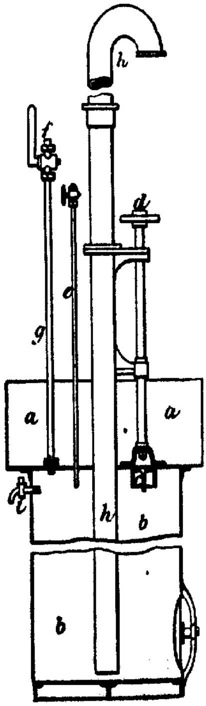


Fig. 237.

liquid by the grease used in their lubrication. Hence the general adoption of the *monte-jus* ("juice-raiser"), one of whose many forms is illustrated in Fig. 62. The body of it consists of 2 chambers *a b*, separated by a steam-

tight diaphragm; the upper chamber *a* receives the syrup to be elevated, while the charge in the lower chamber *b* is in course of elevation, and it is made of suitable capacity for that purpose. When the lower chamber *b* is empty, the valve *c* is raised by turning the handle *d*, while the top of the air-pipe *e* is opened. The syrup contained in the upper chamber *a* immediately descends through the valve *c*, any air that may have been imprisoned in the chamber *b* escaping through the air-pipe *e*. This air-pipe extends about 6 in. into the lower chamber *b*, for the purpose of ascertaining when the chamber is sufficiently full, the escape of air through the pipe *e* being, of course, stopped as soon as the syrup reaches its lower end. The cessation of the whistling noise made by the air rushing through the end of this pipe *e* constitutes the signal for screwing down the valve *c*, to prevent any further flow of syrup into the lower chamber *b*. The air-tap is then closed, and the steam-tap *f* of the steam-pipe *g*, communicating with a steam boiler, is opened, when the empty space between the surface of the syrup and the top of the lower chamber *b* is immediately filled with steam, which at once commences to drive the syrup out through the discharge-pipe *h*. As this pipe is carried down to within a short distance of the bottom of the *monte-jus*, nearly the whole of the contained syrup is forced out of the lower chamber *b*. As soon as any indications of steam appear at the mouth of the discharge-pipe, the steam-tap *f* is shut, and the valve *c* and air-tap *e* are opened to let in a fresh charge.

It will thus be seen that the action of the *monte-jus* is exceedingly simple, only one precaution being necessary, viz. to shut the valve *c* through which the syrup is running, in time. If the syrup be allowed to reach the top plate of the chamber *b*, the steam, when let in through the pipe *g*, will mix with and boil the syrup, but will not elevate it; considerable difficulty and delay sometimes arise from this circumstance. As a precaution against carelessness, an overflow tap *i* should be fitted to the shell of *b*, a few inches below the top, so that the superabundant syrup might be drawn off. In the case of cane-juice, as it comes from the *monte-jus*, it is said to be sufficiently warmed to retard fermentation on its way to the clarifiers.

While this instrument remains by far the most generally adopted means of raising juices and syrups, its superiority has not been unchallenged. It has been objected that its interior is not readily accessible, and that it is therefore difficult to keep clean, whereby fermentation may be caused in juices by the presence of accumulated dirt within the *monte-jus*. It is also urged that the liquor is diluted by the admixture of condensed steam.

Hence, in many cases, the *monte-jus* has been replaced by centrifugal pumps. In favour of these, it is advanced that there are no valves or other mechanism to become a refuge for dirt; no air or steam is forced into the liquor; and, with properly adjusted arms, the juice or syrup is raised in a solid column without churning. Many statements, however, point to the fact that the churning is often seriously worse than with the *monte-jus*. In the best central sugar factories, steam in the *monte-jus* is replaced by air under a pressure of 60 lb. per sq. in., thus obviating most of the drawbacks that have been complained of.

Pumps for Soap and Lye.—Pumps of several kinds are employed in soap-works, for removing spent lye and soap from the coppers. For small pans, a simple hand suction-pump answers; for larger ones a single- or double-acting lift- or force-pump may be placed inside the copper, and worked by hand, or by an eccentric on a shaft. In large factories, some form of centrifugal pump is found useful. Their great advantages are the absence of valves and easily deranged working parts, and the large amount of work they can do in a short time. The pumps made by J. & H. Gwynne, are

in most favour in England; the form usually employed in America is that represented in Figs. 238–240. The pumps require to be connected with pipes having swing joints to permit their being raised and lowered at will. To avoid the pipe system becoming choked by soap congealing in it, a steam-pipe should be inserted at one end, to warm the pipes and pump previous to use, and to "blow out" all their contents at the end of the opera-

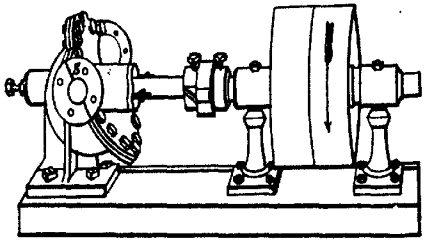


FIG. 238.

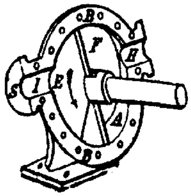


FIG. 239.

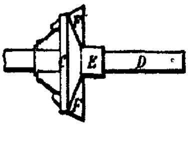


FIG. 240.

tion. In the illustrations, S is the suction-pipe; H, delivery-pipe; F, blades set upon a cone (the rotation of which in the closed case produces the pumping), which is kept in its place by adjustable set screws. This pump will transfer to any desired part of the factory, lye, melted fat, finished soap (if not too stiff), "nigre," and soft curd. The diameter of the pump is 10 in., of its outlet 2½ in.; when making 120 rev. a minute, it will pump 6000 gal. an hour, its contents being twice emptied in each revolution.

Siphons.—Where fluids have to be transferred from an upper to a lower level, passing on the way over an obstacle of greater height than the upper vessel, a siphon may conveniently replace a pump, as, once the stream is started, it will continue flowing indefinitely until the level of the liquid in the supply vessel becomes so low as to admit air into the siphon.

In its simplest form, the siphon is merely a pipe bent into a ∩ shape, with one leg longer than the other: the shorter leg is placed in the liquid which is to be drawn off. To start the siphon, it is necessary to empty it of air and fill it with the water or fluid to be siphoned; this is best accomplished by turning it end upmost and pouring the liquid in at the longer leg till it overflows, the thumb being meanwhile held over the orifice in the shorter leg. Both ends are stopped in this way

while inverting the siphon into the vessel to be drawn from, and care must be taken not to remove the thumb from the mouth of the longer leg till after the shorter leg is free to draw its supply.

(a) The operation of a siphon depends on the source of supply being above the level of the point where it is to be delivered. Of course if a straight pipe can be run from the high to the low point it would be best, but if a high object or place exists between the two points then siphonage may be resorted to. The example illustrated in Fig. 241 represents a case where a house has a long piece of ground, about two acres, at the rear. The ground rises from the house, and at the highest point good water is obtainable at 12 feet depth. This is well above the level of the sinks in the house, but as a trench, 12 to 14 feet deep, could not be sunk to lay a straight pipe from the well, a 1-inch siphon service was laid as indicated, and has always worked satisfactorily. As the movement of water through a siphon is due to atmospheric pressure, no siphon can have its highest point more than 34 feet above the source of water, and in practice it is well not to exceed 28 feet, and then only when the long leg of the siphon is several feet lower than the waterline at the source.

FIG. 241.

A trouble is experienced with siphons when they become air-locked. There is, however, a moderately simple provision that may be made, not to prevent the trouble—as this is impossible—but to remedy it easily. Fig. 242 shows the arrangement, which also answers the useful purpose of a filling-point for the siphon. It should be fitted up at the highest point of the siphon, and at all high points if the delivery-pipe does not preserve a gradual fall from its highest point to its discharge end. To discharge air (which collects in the chamber A) close the cock B, then open C. The air from chamber A will escape, and water take its place. Now close C and open B, and any air below the latter will rise up into the chamber A and water descend to take its place. This, it will be seen, enables air to be discharged without emptying or stopping the normal work of the siphon, and the time occupied in doing this is

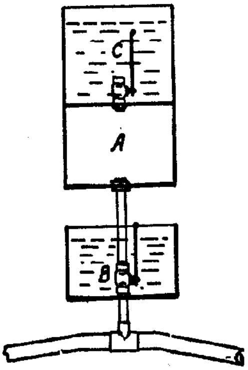


FIG. 242

a few minutes only. The upper pan or tank, in which the cock C is situated, is kept filled with water, for the purpose already explained, whilst the lower pan, around the cock B, is provided to water-seal this latter cock.

The efficiency of this air-discharging appliance is greatly assisted by avoiding the use of any horizontal pipe at the highest point or points in the syphon. Horizontal pipe will have great air-bubbles collect and hang along inside it, first impairing the flow of water and subsequently stopping it, and whatever provision is made for air-discharge will fail to properly remove this accumulation. These high points should be little more than points, and the rise and fall to and from them should not in any part be less than 1 in 20. Unless the water passing through the pipe has velocity enough to scour the air out, it will stay there and give trouble.

(*b*) When, at an elevated point in a meadow, there exists a spring or vein of water that cannot be utilised at a distance, either because the supply is not sufficient, or because of the permeability of the soil, it becomes very advantageous to accumulate the water in a reservoir, which may be emptied from time to time through an aperture large enough to allow the water to flow in abundance over all parts of the field. The storing up of the water permits of irrigating a much greater area of land, and has the advantage of allowing the watering to be effected intermittently, this being better than if it were done continuously. But this mode of irrigating requires assiduous attention. It is necessary, in fact, when the reservoir is full, to go and raise the plug, wait till the water has flowed out, and then put in the plug again as accurately as possible —a thing that is not always easy to do. The work is a continuous piece of drudgery, and takes just as much the longer to do in proportion as the reservoir is more distant from one's dwelling. In order to do away with this inconvenience, Giral, of Langogne (Lozère), has invented a sort of movable siphon that primes itself automatically, however small be the spring that feeds the reservoir in which it is placed. The apparatus (Fig. 243) consists of an elbowed pipe C A B D E of galvanised iron, whose extremity C communicates with the outlet R, where it is fixed by means of a piece of rubber of peculiar form that allows the other extremity B D E to revolve around an axis, while at the same time keeping the outlet pipe hermetically closed. This rubber, whose lower extremity is bent back like the bell of a trumpet, forms a washer against which is applied a galvanised iron ring that is fixed to the mouth of the outlet pipe by means of 6 small screws. This ring is provided with 2 studs, which engage with 2 flexible thimbles, affixed to the siphon by 4 rivets. These studs and thimbles, as well as the screws, are likewise galvanised. Between the branches A B D E of the pipe is soldered a sheet of galvanised iron, which forms isolatedly a receptacle or air-chamber F, that contains at its upper part a small aperture *b*, that remains always open, and, at its lower part, a copper screw-plug *d* and a galvanised hook H. In the interior of this chamber is arranged a small leaden siphon *a b c* whose longer leg *a* passes through the bottom, where it is soldered, and whose shorter one *c* ends in close proximity to the bottom. Finally, a galvanised iron chain G H, fixed at G to the bottom of the reservoir, and provided with a weight P of galvanised iron, is hooked at H to the siphon and allows it to rise more or less, according as it is given a greater or less length. From what precedes, it will be seen that the outlet is entirely closed; so that, in order that the water may escape, it must pass into the pipe in the direction E D B A C. This granted, let us see how the apparatus works: in measure as the water rises in the reservoir, the siphon gradually loses weight, and its extremity B D H is finally lifted by

the thrust, so that the entire affair revolves upon the studs, until the chain becomes taut. The apparatus then ceases to rise; but the water, ever continuing to rise, finally reaches the apex b of the smaller siphon, and through it enters the air-chamber and fills it. The equilibrium being thus broken, the siphon descends to the bottom, becomes primed, and empties the reservoir. When the level of the water in descending is at the height of the small siphon a b, this latter, which is also primed, empties the chamber F in turn, so that, at the moment the large siphon loses its priming, the entire apparatus is in the same state that it was at first. In short, when the water enters the reservoir, the siphon, movable upon its base, rises to the height at which it is desired that the flow shall take place. Being arrested at this point by the chain, it becomes primed and sinks, and the water escapes. When the water is exhausted, the siphon rises anew in order to again sink; and this goes on as long as the period of irrigation lasts. This apparatus, which is simple in its operation, and not very costly, is being employed with success for irrigating several meadows in the upper basin of the Allier. ('Le Génie Civil.')

(*e*) As well known, the general solution of the problem of storing water, a vital question for agriculture, is the following: to unite all the sources that are not utilisable, on account of their too feeble discharge, in a reservoir of appropriate dimensions, which is emptied one or more times in 24 hours through a sluice of dimensions such that the water collected can be entirely distributed over the surface to be irrigated, in a relatively short time. Experience, in fact, has proved that if water is profitable when distributed to profusion, it is but slightly so when it flows in a thin stream in a trench of which it wets only the banks.

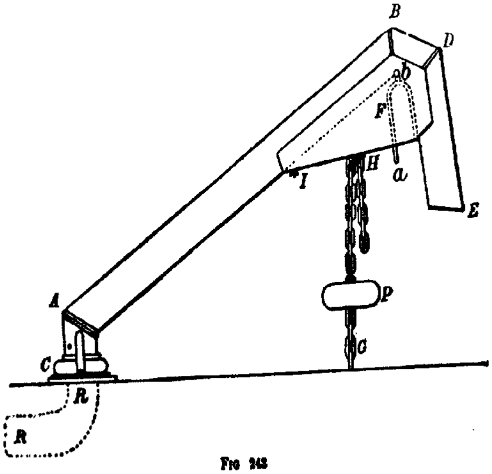


FIG 243

Instead of having a sluice to be opened at definite intervals, it long ago occurred to some persons to make use of the ordinary siphon. It suffices, in fact, that the latter shall prime itself automatically in order to have a rapid and intermittent emptying of

the reservoir. But the conditions necessary for such automatic priming are sometimes difficult to carry out. The source, in fact, must be very regular, and have a pretty large discharge, larger than that of the siphon during the short space of time in which the latter, operating at first as a waste pipe, is upon the point of priming itself. If this critical point is passed, the priming is effected and the reservoir is emptied by reason of the greater velocity that the head of water gives the liquid in the siphon.

But if the source is intermittent, irregular, or diminishes, it may happen that the siphon will no longer perform the functions of anything but a waste pipe. Priming will no longer be able to be effected, and the abrupt emptying of the reservoir will no longer take place.

In certain special cases, this state of things can be remedied by establishing a well of water for the reception of the long branch of the siphon. The overflow is thus reduced and the priming can take place.

This, in reality, is merely a palliative of a result that is so uncertain in all cases that it is usually perferred to empty the reservoir by opening a sluice at stated intervals. Hence an annoying restraint, and a very poor utilisation of the water at one's disposal.

In fact, the user generally opens the sluice in the morning and evening. Between these two intervals and at night, if the reservoir is full, the water flows out slowly, and irrigates but a small surface.

Different means have been proposed for obtaining an automatic discharge, and especially for preventing the ever possible neglect to manœuvre the sluice. At the last agricultural exhibition at Tulle was shown a recently devised and very simple system, the great advantage of which is the entire absence of any mechanism whatever subject to get out of order. It is a siphon, but it has been so arranged by Delavallade that the problem is entirely solved despite all the difficulties enumerated. Fig. 244 gives a general view of the apparatus and the manner in which it is arranged in the sluice hole of a reservoir. Thus placed, and supported by 2 wooden posts, one has no longer to pay any attention to it. Whatever be the irregularities in the

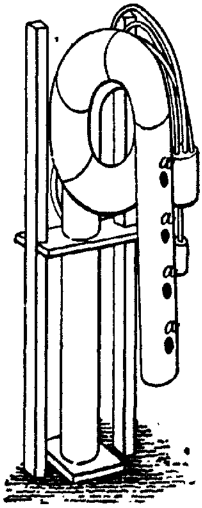


FIG. 244.

discharge of the source, the siphon will never act as a waste pipe, and will prime itself as soon as the desired level of water is reached in the reservoir.

The latter once empty, the siphon will be unprimed, and will reprime itself a few hours later. The instant of unpriming, and consequently the level of the water remaining in the pond, is fully under the control of the farmer. It suffices, in fact, to form a series of apertures *a* in the short branch of the siphon, and close them with wooden plugs that are removed according as it is desired that the water shall descend to such or such a level in the reservoir.

As shown in the sections in Figs. 245, 246, the apparatus is constructed in two different forms, but the principle of both is absolutely the same.

The bell siphon (Fig. 245) consists of a tube, which is inserted in the sluice

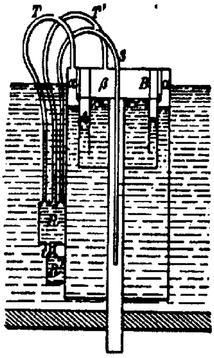


FIG. 245.

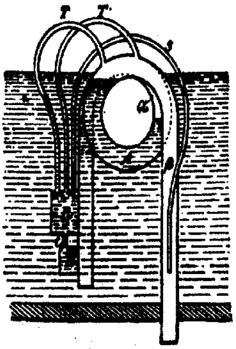


FIG. 246.

hole and is provided at its upper part with a circular water reservoir A. A movable bell, provided with an internal circular diaphram B, covers the whole and rests upon the tube. It is provided with two small external reservoirs R R' connected by a tube t. The lower reservoir R' communicates with the interior of the bell, through small apertures.

Two bent tubes T T' put the reservoir R in communication with the two chambers α β formed in the bell by the diaphragm B. A third tube S below the two others, starts from the reservoir R, traverses the bell, and hangs vertically in the interior of the central tube fixed in the sluice.

Fig. 246 represents the second form of the apparatus. It is an ordinary doubly revolving siphon. The general arrangements are the same as those just described. It is to be remarked that the part A of the bent siphon will always remain full of water, like the reservoir A in the bell siphon.

Let us suppose that the pond has just been emptied; the unprimed siphon will be entirely empty, except in the parts A. The water gradually rises in the reservoir, and consequently in the short branch of the siphon, in the reservoir R, through the intermedium of the reservoir R', and in the three tubes T T' S. In measure as the water rises, the air is driven forward until the moment that the siphon is about to operate as a waste pipe. It thus takes a certain pressure in the chamber α (tube T), on account of the presence of water in the internal reservoir A. In the chamber β, on the contrary, it remains at the pressure of the atmosphere, since the long branch of the siphon opens in the free air. It is starting from this moment that the automatic priming of an ordinary siphon may take place, if the requisite conditions of discharge be present, the air confined in the upper parts being carried along by the first jet of the liquid. If such conditions are not fulfilled, there always remains in the upper part of the siphon or of the bell some air that must be got rid of, or the pressure of which it will suffice to diminish sufficiently to produce an abrupt ascending motion of the internal liquid column, and consequently a priming.

Such is the principle to be applied,

and the way it is done is as follows: In consequence of the presence of a certain volume of compressed air in the internal chamber α, the velocity of the siphon's flow as a waste pipe is infinitely small, and increases proportionally much more slowly than under ordinary circumstances with the external level of the liquid. It results from this, that whatever be the discharge of the source, the tube S, placed beneath T and T' will be very quickly immersed.

In reality, this tube is merely an auxiliary siphon whose diameter is small enough to allow its priming to be always certain. It will therefore empty the reservoir R almost instantaneously. As, on another hand, the latter can fill itself but slowly, on account of the small diameter of the tube t, there will occur, in order to fill the vacuum formed, an abrupt draught and a putting in equilibrium (through the tubes T T') of the air occupying the internal chambers $\alpha\ \beta$. At this very moment, the jet of water issuing from the auxiliary siphon in the central tube, or the long branch of the siphon, causes a suction in the chamber β, and establishes in the whole ($\alpha\ \beta$) a pressure sensibly less than that of the atmosphere. From this complete rupture of equilibrium between the internal liquid and gaseous strata of the siphon, results a sort of ram stroke that effects an automatic priming. From the very beginning, the remaining air is carried along by the liquid, with a considerable velocity, dependent upon the height of the water in the pond, which latter rapidly empties until the apparatus is unprimed.

The system, with a few slight modifications of detail, is applicable as follows: 1, to the flushing chambers in the sewers of large cities; 2, to the submersion of meadows, and in general to all the problems of irrigation; 3, to the automatic emptying and renewing of the water in garden fountains and in ponds especially set apart for pisciculture; 4, and, finally, to the draining of quarries, mine holes, etc., without machines, provided there be a low point for the flow. ('La Nature.')

Figs. 247, 248 show handy glass siphons adapted for small operations, the former being without, the latter

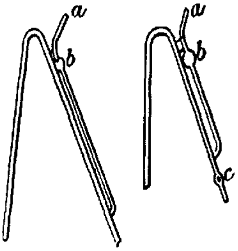


FIG. 247.

with, stop-cock c for regulating the flow. The current is started in these by applying the mouth to the end a of the tube, and employing it as an air-pump to exhaust the air till the fluid rises into the bulb b. With

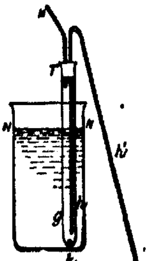


FIG. 248.

harmless liquids, a simple bent glass tube may suffice as a siphon; but suction with the mouth at the end of the longer arm is somewhat inconvenient. The arrangement shown in Fig. 248 is simple, and presents certain advantages: A glass tube g, ½ in.

wide, and 12-16 in. long, contracted at the lower end, has, at its upper end, a cork stopper, in which the mouthpiece M and the siphon $h\ h'$ are fixed air-tight. The shorter arm h of the siphon reaches nearly to the bottom of the tube, and limits the play of a glass ball k, which acts as a valve. The diameter of the ball is about ½ in., that of the siphon ¼ in. The instrument thus arranged, being dipped into the vessel to be discharged, the tubes g and h become filled with liquid to the surface N N. Instead now of sucking, as with the common siphon, one blows into the mouthpiece M; and in consequence of the compression of air, the lower opening is shut by the ball k, while the liquid rises in h, and begins to flow through h' in the usual way. If the vessel to be emptied is not full, or the column of liquid is a small one, it is necessary before blowing into the mouthpiece, to suck it slightly, in order to obtain a larger volume of the liquid in g; as one condition for the right action of the instrument is that $h\ h'$ should be filled before the column of liquid in g sinks to the mouth of the siphon at k, when one blows through M.

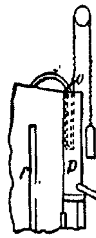


FIG. 249.

Fig. 249 shows a method of constructing a siphon suited for drawing off large quantities of hot or corrosive liquids (the dimensions given being adapted to sulphuric acid boiling pans). In the figure, n is a leaden siphon, 1½ in. bore, through which acid is to be drawn from the pan, that lies hidden in brickwork behind the stay bar f; o is a leaden cup, 18 in. deep, 4 in. diameter, attached to a weight by a chain passing over a pulley. This cup is filled with acid; the siphon is also filled with acid, and set with one leg in the pan and the other in the cup. When the cup is lowered, the acid flows through the siphon and overflows the cup, running into p, a leaden box, 3 ft. 3 in. deep, and 9 in. diameter, whence it flows through q, a leaden pipe leading to cooler or retorts. When the cup is raised, so much that the top of it is above the level of the acid in the pan, the acid ceases to flow. In the drawing, the cup is shown raised to its highest, the top being a little above the level of the top of the pan, so that were the pan quite full of acid, none would run out until the cup was lowered. The cup keeps the siphon constantly set; but if all the acid were drawn from the pan, air would enter the pan leg of the siphon, and it would become unset. Similar siphons are used for drawing acid out of the chambers.

Fig. 250 shows a portion of another form of siphon, generally used for

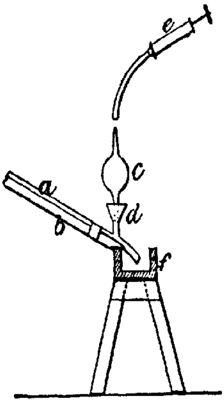


FIG. 250.

drawing off sulphuric acid from the retorts in which it is concentrated, but equally useful for many other purposes. The siphon a is formed of a piece of ½-in. bore leaden pipe, bound to a small strip of wood b; c is a glass globe with 2 tapering tubes, the end of one tube being inserted into a leaden

funnel *d*, in which *c* is hermetically sealed by a mixture of melted brimstone thickened with a little sand; *e*, an exhausting syringe, to the mouth of which is attached a short piece of rubber tubing. To set the siphon, one person takes a small piece of sheet rubber, say ⅛ in. thick, and holds it tightly against the mouth of the siphon, to stop the passage of air, whilst a second person takes the syringe and slips the end of its flexible tubing over the end of the upper tube of the glass globe. On working the syringe a few strokes, the air becomes exhausted from the siphon, causing the acid to flow through it, and commence to fill the glass globe. The syringe is then removed, and the piece of rubber is quickly withdrawn from the mouth of the siphon; the acid continues to flow until the retort is nearly empty. A wooden trough *f* lined with lead (shown in section), catches the acid from the siphon, and leads it to the cooler.

A siphon setting apparatus is shown in Fig. 251; *a* is the siphon; *b*, a closed leaden vessel; *c*, an open vessel or bucket. A small metallic pipe connects the top of the siphon with the top of the vessel *b*, and a rubber tube

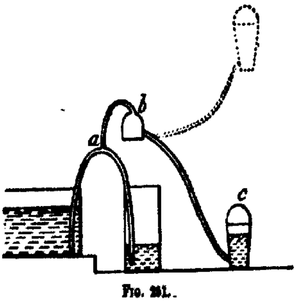


FIG. 251.

connects the bottom of *b* with the bottom of *c*. To set the siphon (both legs of which must be standing in liquid), fill the bucket with water, raise it above *b*, and hold it there till all the water has run into the vessel *b*. Then stand the bucket down, and the water will flow back into it; the vacuum thereby created in *b* will exhaust the air from the siphon, and set it running.

To obtain a uniform flow of acid or other liquid under varying degrees of

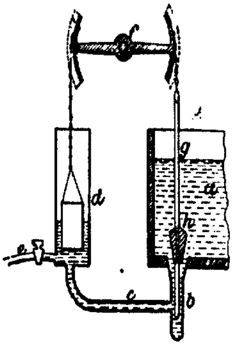


FIG. 252

pressure, the apparatus shown in Fig. 252 is used. *a* is a cistern containing acid or other liquid; *b*, a well in the cistern having a conical mouth; *c*, a pipe connecting the well and cistern with the cylindrical vessel *d*, which must be the same height as *a*; *e*, a delivery-pipe fitted with a tap; *f*, a lever working on a central pivot. One end of the lever is attached by a chain to a leaden bucket which hangs in the vessel *d*, and the other end is attached by a short chain to the rod *g* (which is of iron cased in lead), having cast on it the conical plug *h*, which must fit accurately the contracting mouth of the well *b*. The extension of the rod below the plug serves to keep the latter in its seat. The tap in the pipe *e* being opened, the greater the pressure of acid in *a*, the higher it will rise in *d*, elevating the bucket and depressing the plug *h*, which will check the flow.

Thus, at whatever height and consequent pressure the liquid in the cistern may be, the pressure or flow from the delivery-pipe will be uniform.

The following arrangement of siphon is little known, though used at various times, and for various purposes, the

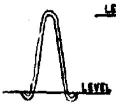


FIG. 253.

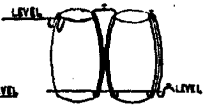


FIG. 254.

last 20 years. It simply consists in having the ends of an equal legged siphon bent up as in Fig. 253. When the above is once charged, and the openings kept level, it will draw the liquid from a vessel, stopping, of course, when the level of the liquid reaches that of the openings, but will start into action again if the level of liquid rises. Chemical readers will find a glass tube, bent as above, very handy in the laboratory for decanting, as, when not in use, it can be hung ready charged on a nail against the wall. The principle may be applied to a couple of rain-water butts, with the object of not cutting the casks in any way below the water-line, obviating oozing and dropping—the common complaint about the connection of water-butts. It answers very well. Fig. 254 is the arrangement. Put a long turn-up on the overflow siphon—about 9 in.—so that evaporation can take place to some extent without interfering with the stability of the water in the pipe. For charging the two long siphons, have a small gas tap soldered on the top of each, through which to suck out the air, after which screw up the little nut or plug of taps very tight so that they cannot be opened by meddlesome fingers. The overflow may be charged in a tub of water, and afterwards adjusted on edge of cask so as to keep the level about 1 in. from top when raining heaviest. The siphon for laboratory use above mentioned, could be improved by making one of the legs straight, and fixing it to a piece of rubber tube with a pinch tap. Arranged thus it could be carried about without fear of upsetting the balance of the water in the two legs.

The numerous experiments in disinfecting with sulphurous anhydride have shown that the chief difficulty in the way of various applications of it reside in the imperfection of the apparatus designed for holding and distributing this liquefied gas under strong pressure. As this agent is called upon to render great services in a host of cases in which the sulphurous acid pro-

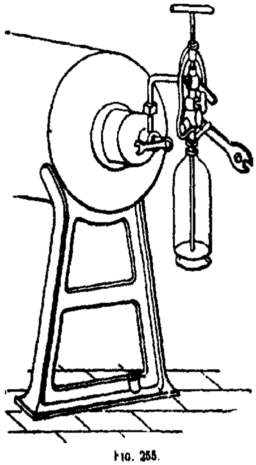


FIG. 255.

duced by the direct combustion of sulphur, and without pressure, cannot be used, it is of importance to prevent to as great a degree as possible any leakage, and to be able under all circumstances to easily bottle, carry, handle, and apply this powerful dis-

infectant. After many experiments, Dr. Victor Fatio, of Geneva, has succeeded in constructing for this purpose an apparatus that permits of quickly and safely charging siphons from the fountains in which the anhydrous sulphurous acid is delivered to consumers.

Fig. 255 shows one of the siphon apparatus being charged with sulphurous acid from one of Pictet's metallic fountains. The specially arranged siphon is provided at the upper part with a tube, by means of which it is put in communication with the fountain through a bent tube. To the siphon there is adapted a key which permits of opening and closing it before and after the introduction of the liquefied gas. Another key is fitted to the fountain. At the upper part of the device, which rises when the siphon is full, there is a handle for tightening it up. For disinfecting a room by means of a siphon of sulphurous acid, it suffices to empty some of the liquid into a basin and allow it to evaporate. By means of a rubber tube running through a hole in the door or wall, a room may be disinfected from a siphon placed outside. ('La Nature.')

Bode and Wimpf have designed a new kind of siphon, which is of great use for siphoning off acid, caustic or poisonous liquids. Its special feature is due to the fact that it is not set by suction, but by blowing, so that the liquid to be siphoned off can never get into the mouth. Fig. 256 represents the construction. The tube D is surrounded by a wider one C closed at the top, and provided with a ball-valve B at the end E. On putting the apparatus into a liquid, the ball valve is raised, and the tubes C and D are filled to the height of the surrounding liquid. If now air be blown into the tube H, the valve is closed, and the liquid being driven from C into D and F sets the siphon to work. The blowing is then discontinued and H is closed. If it be desired to interrupt the flow it is only necessary to blow a little stronger through H. The valve B is now pressed into its seat, and no liquid being able to enter the siphon, it empties itself. The siphon

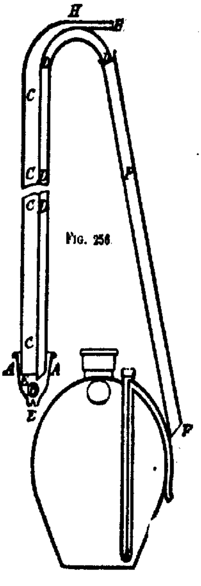


FIG. 256.

FIG. 257.

need never be removed from the liquid either at the start or at the end. It can be made of glass, earthenware, ebonite, rubber, and metal. It is also intended to fit Woulff's bottles with this siphoning arrangement, as shown in Fig. 277, for drawing off acids in the course of the manufacture. ('Chem. Zeit.')

END OF VOLUME III.

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